Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.1

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

No Appendix- Placeholder

December 24,2014

Bill Walker
Governor

Larry Hartig
Commissioner

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Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.2

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

Adopted

December 24, 2014

Bill Walker
Governor

Larry Hartig
Commissioner

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Appendix III.D.5.02

Initial Design Letter

Initial Design Supplemental Information

Fairbanks Metropolitan Area Transportation System (FMATS)
Intergovernmental Operating Agreement and Memorandum of Understanding
for Transportation & Air Quality Planning, dated March 28,
2003.

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Adopted December 24, 2014

STATE OF ALASKA

DEPT. OF ENVIRONMENTAL CONSERVATION
OFFICE OF THE COMMISSIONER

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December 14, 2007

Elin D. Miller, Regional Administrator
Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Re: Alaska Governor's Recommendation for $PM_{2.5}$ Area Designation

Dear Ms. Miller:

On behalf of Governor Palin, the Alaska Department of Environmental Conservation provides the following recommendations for designation of areas for the revised fine particle air quality standard ($PM_{2.5}$). Please accept this letter as an initial designation in accordance with the requirements of Section 107(d)(A) of the Clean Air Act.

Air quality measurement data was collected for the past three years in four areas of Alaska: Anchorage, Fairbanks, the Mendenhall Valley in Juneau, and the Butte area in the Matanuska-Susitna Borough. The data shows only one community that is exceeding the health based 24-hour exposure limit of 35 micrograms per cubic meter ($\mu g/m^3$) of air: Fairbanks. The Mendenhall Valley in Juneau is very close, but not exceeding the standard limit based on the 2004-2006 data. The situation in Juneau will need to be closely monitored as data collection continues into the future. All the monitoring sites showed attainment for the annual exposure limit of $15\mu g/m^3$.

Compliance with the health standard was determined by evaluating three years of ambient monitoring data in accordance with EPA's requirements under 40 CFR Part 50 Appendix N. The annual design value is the three year average of the annual means of the observed concentrations at each site. The 24-hour design value for each monitoring site is based on the 98th percentile concentration observed for each year, averaged over three years. Table 1 lists the 24-hour and annual design values for the four monitoring locations in comparison to the health standards:

Table 1. Comparison of Alaska's $PM_{2.5}$ Design Values with the $PM_{2.5}$ Health Standards

$PM_{2.5}$ Design Value	Health Standard, ($\mu g/m^3$)	Anchorage, ($\mu g/m^3$)	Fairbanks, ($\mu g/m^3$)	Mendenhall Valley, Juneau, ($\mu g/m^3$)	Butte, Matanuska-Susitna Borough*, ($\mu g/m^3$)
24-hour	35	26	43	35	31
Annual	15	6.7	11.0	7.8	6.0

* Note: The data for the Butte area in the Matanuska-Susitna Valley is missing for the second and third quarters in 2004. See enclosure for additional information.

Based on this data, Table 2 provides Alaska's designation recommendations:

Table 2. Alaska's $PM_{2.5}$ Designation Recommendations

Community/Area	Designation Recommendation	
	Annual Standard	**24-hour Standard**
Anchorage	Attainment	Attainment
Fairbanks	Attainment	Non-Attainment
Mendenhall Valley, Juneau	Attainment	Attainment
Butte, Matanuska-Susitna Borough	Attainment	Attainment
Other Areas of Alaska	Attainment	Unclassifiable

In 2004, Alaska recommended that the Environmental Protection Agency designate all areas of the state in attainment for the annual standard of $15\mu g/m^3$. We believe that with the retention of the standard at the same level, our original recommendation still holds true for all areas of Alaska. However, with the increased stringency of the 24-hour standard and increasing fuel costs that have renewed interest in wood-fueled heating, we cannot be certain that all areas of Alaska are in attainment. Therefore, we recommend that those areas which do not have monitoring data be designated unclassifiable. Enclosed is supporting information and analysis regarding these designation recommendations as well as our recommended boundary for a Fairbanks 24-hour $PM_{2.5}$ non-attainment area.

Please contact Tom Chapple, Air Quality Division Director, at (907) 269-7634 if you or your staff has any questions about Alaska's recommendations for the fine particle, $PM_{2.5}$, air quality standards.

Sincerely,

Larry Hartig
Commissioner

cc: The Honorable Sarah Palin, Governor
Jim Whitaker, Mayor Fairbanks North Star Borough
Rod Swope, City Manager, City & Borough of Juneau

Enclosure

Supplemental Information
Alaska Department of Environmental Conservation
$PM_{2.5}$ Designation and Boundary Recommendations

I. $PM_{2.5}$ Design Value Calculations

Below is a table showing the calculated 24-hour and annual $PM_{2.5}$ design values for locales represented by Alaska's $PM_{2.5}$ monitoring network.

	Anchorage	Matanuska Susitna Valley-Butte	Juneau – Mendenhall Valley	Fairbanks
24-hour $PM_{2.5}$ design value	**26**	**31**	**35**	**43**
annual $PM_{2.5}$ design value	**6.7**	**6.0**	**7.8**	**11.0**

The table below shows the number of days the new standard was exceeded each year at each location. The timeframe for this designation calculation is 2004-2006. The 24-hour values in bold font for each site were the 98th percentile values averaged for the 24-hour design values. The new $PM_{2.5}$ health standard went into effect on Dec. 18, 2006. Consequently, these locales were managed to less rigorous National Ambient Air Quality Standard (NAAQS) throughout 2004-2006.

	Anchorage			Matanuska Susitna Valley - Butte			Juneau – Mendenhall Valley			Fairbanks		
Calendar Year	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**
Max. 24-hr Concentration, μg/m^3	43.7	55.9	34.1	**27.5**	45	48.6	29.8	45.1	48.5	54.2	60	51.9
2nd Max. 24-hr Concentration, μg/m^3	32	33.3	30.7	23.3	25.2	**40**	**27.5**	**39.9**	**36.7**	**46.2**	**40.6**	**42.2**
3rd Max. 24-hr Concentration, μg/m^3	**31.9**	**17.9**	**26.9**	20.3	**25.2**	39.4	26.1	35.4	33	38.1	34	41.1
Days above new standard	**1**	**1**	**0**	**0**	**1**	**4**	**0**	**3**	**2**	**3**	**2**	**4**
24-hour design value, μg/m^3	**26**			**31**			**35**			**43**		
annual design value, μg/m^3	**6.7**			**6.0**			**7.8**			**11**		

The data for the Butte area in the Matanuska-Susitna Valley has two missing quarters in 2004. No data was collected during the second and third quarters due to staff turnover. Higher concentrations of $PM_{2.5}$ are typically measured during the winter months (i.e. the first and fourth quarters). Thus, the design value was calculated with the remaining data values for 2004.

II. Fairbanks $PM_{2.5}$ Non-Attainment Boundary Analysis

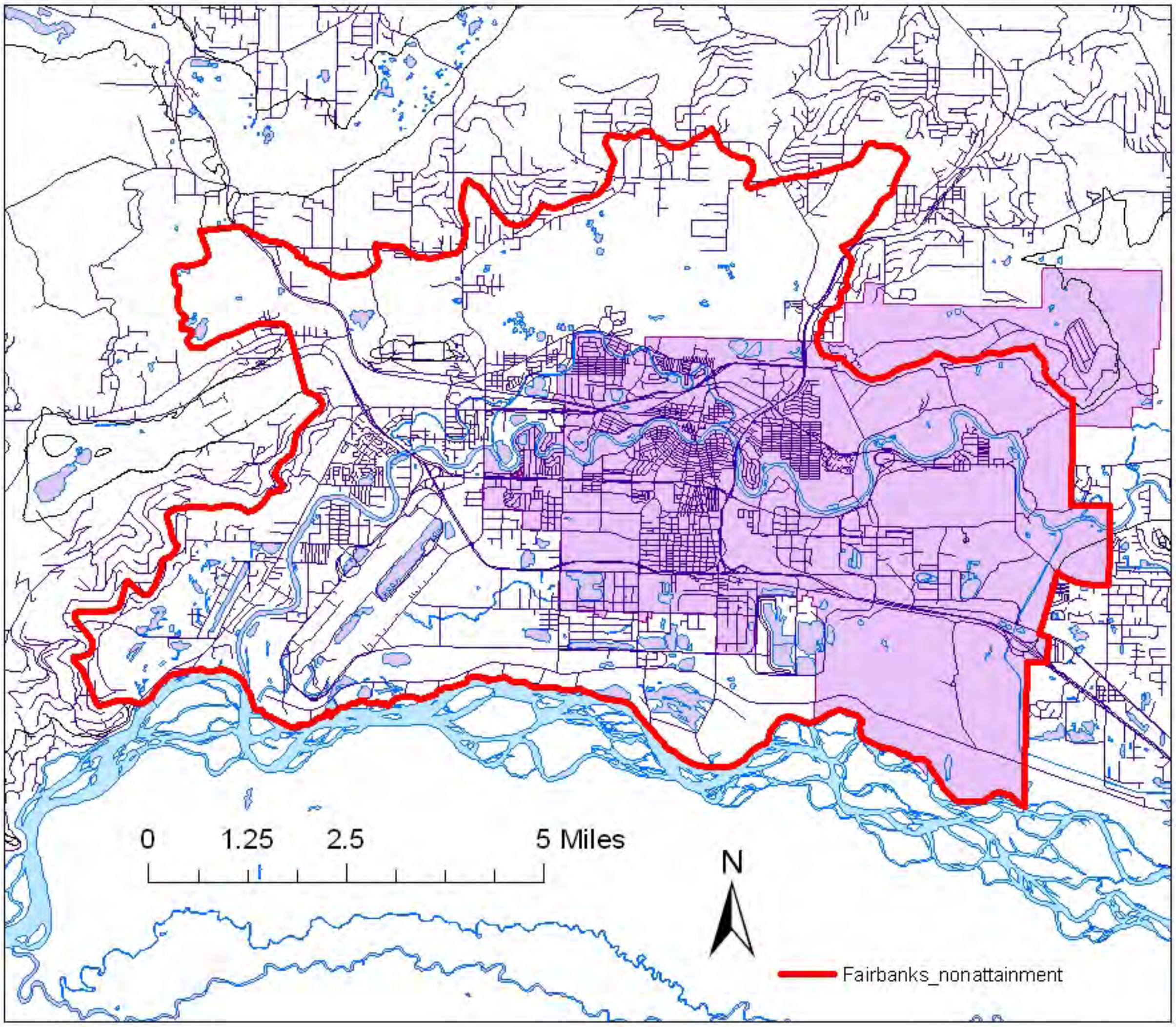
Ambient air monitoring has been conducted at one site in downtown Fairbanks since the $PM_{2.5}$ network was established in 1999. While this site does represent the level of fine particulates in the downtown area, there is nothing to confirm that $PM_{2.5}$ concentrations exceed state and federal fine particulate standards outside of the urban center. EPA recommends that states consider nine factors in making non-attainment boundary recommendations. These nine factors include:

- Emission data
- Air Quality data
- Population density and degree of urbanization (including commercial development)
- Traffic and commuting patterns
- Growth rates and patterns
- Meteorology (weather/transport patterns)
- Geography/topography (mountain ranges or other air basin boundaries)
- Jurisdictional boundaries (e.g. counties, air districts, reservations, metropolitan planning organizations (MPOs)
- Level of control of emission sources

Based on a number of these factors, the department, in consultation with the Fairbanks North Star Borough, has developed a recommended boundary for a $PM_{2.5}$ non-attainment area in Fairbanks. The proposed boundary, depicted in Figure 1, captures the airshed most likely to be in non-attainment of the health standard based on existing monitoring data and other factors listed above. As supplemental information and data is collected over the next several years, this boundary could be further refined.

The proposed Fairbanks non-attainment area would be bounded on the south by the Tanana River. The western and northern boundary would occur at the 600 foot elevation on the surrounding hills and ridges. The eastern boundary would also extend along at the 600 foot elevation level until it reaches the eastern edge of the Fairbanks city boundary (also the Fort Wainwright military reservation boundary). The eastern boundary would then continue to extend south along the city boundary until it meets the Tanana River. Figure 1 shows a map of the proposed boundary.

Figure 1
Proposed Fairbanks $PM_{2.5}$ Non-Attainment Area Boundary Map



$PM_{2.5}$ Air Quality in Fairbanks

In 1997, the national ambient air quality standard for $PM_{2.5}$ was 15µg/m^3 for an annual average and 65µg/m^3 for a 24-hour average. As of August 2007, the U.S. Environmental Protection Agency (EPA) had determined that Fairbanks was in attainment of the 65 µg/m^3 standard. In 2006, the 24-hour standard was tightened by EPA[1*] to 35µg/m^3. In each of the three winter periods (Oct-Mar) from 2004–2007 Fairbanks experienced 25-30 days when the daily average $PM_{2.5}$ exceeded 35µg/m^3 (based on measurements recorded on continuous analyzers), with yearly 24-hour average maxima ranging from 65 to 88µg/m^3 as measured by either federal reference monitors or continuous monitors. The 24-hour $PM_{2.5}$ design value calculated for Fairbanks during the period 2004-2006 is 43µg/m^3.

Uncertainties in Air Monitoring Data

While the state believes winter monitoring results have shown a 24 hour $PM_{2.5}$ problem in Fairbanks, the data has some limitations that could possibly invalidate most of the winter data. First, the federal reference method samplers frequently operated at temperatures below the design range of the instruments making flow readings, particle movement, and general low-temperature operation uncertain. Problems with calibrator operations at extreme cold temperatures further impacts monitoring results. In addition, it is known that the Federal Reference Method filter-based sampling does not properly adjust for changing sample flow rates at the lower temperatures experienced in Fairbanks in winter.

At the same time, the Fairbanks North Star Borough operated a Met One Beta Attenuation Monitor to provide a more robust assessment of fine particle concentrations. Because these samplers are not federal reference methods or federal equivalent methods, they were operated to collect co-located measurements with the federal reference method samplers. During the evaluation period, the continuous sampler design was undergoing modifications and upgrade. A heater was installed in 2007 to help control humidity which may have caused readings to be subject to a positive artifact,[2] and measurements made after that time may be subject to a negative artifact due to loss of nitrate (which has been observed in other samplers when an in-line heater was used).[3]

Geography/Topography

The state's proposed $PM_{2.5}$ nonattainment area boundary centers on the city of Fairbanks which is located in interior Alaska at 64.837780° North Latitude, -147.71639° West Longitude. The city lies on the winding Chena River near its confluence with the Tanana River, which occurs just south of town. The city is surrounded by ridges on the northeast, north, and west. The Chatinika, Chena, and Salcha River drainages define the area surrounded by rolling hills to the north, east and west of the urban centers. The Tanana River Valley flats border the city to the south and southeast.

[*] Superscripts denote references provided at the end of this document.

The elevation of Fairbanks on the valley floor is approximately 440 feet above sea level (ASL) with the immediate surrounding ridges rising to about 600 feet ASL and other ridges close by that reach as much as 2500 feet ASL. The low elevation of the city center with respect to the surrounding ridges causes air pollution build up within the bowl during stagnant air conditions.

The nearby city of North Pole lies to the southeast of Fairbanks on the valley floor in a less topographically confined region, with the closest hills lying to the east at a greater distance from the North Pole city center than the hills surrounding downtown Fairbanks.

Meteorology

Fairbanks winters are dominated by a pattern of cold, stable air that supports the buildup of air pollutants.[4,5] Temperatures typically range between -20° and +20° F, with several periods of -40° F each winter. Occasionally, temperatures can extend to much colder temperatures (e.g. -66° F). 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 an overlying air. Fairbanks frequently experiences 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. This condition together with local emissions of $PM_{2.5}$ and its precursors (especially sulfur dioxide) can cause episodes of elevated $PM_{2.5}$ concentrations.

Location and 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. The area encompasses 7,361.0 sq. miles of land and 77.8 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, FMATS, whose boundary includes both Fairbanks and North Pole and extends further into population areas within the vicinity of both communities.

Figures 2 through 4 are maps of the borough, cities, and FMATS boundaries.

Figure 2 - Fairbanks North Star Borough

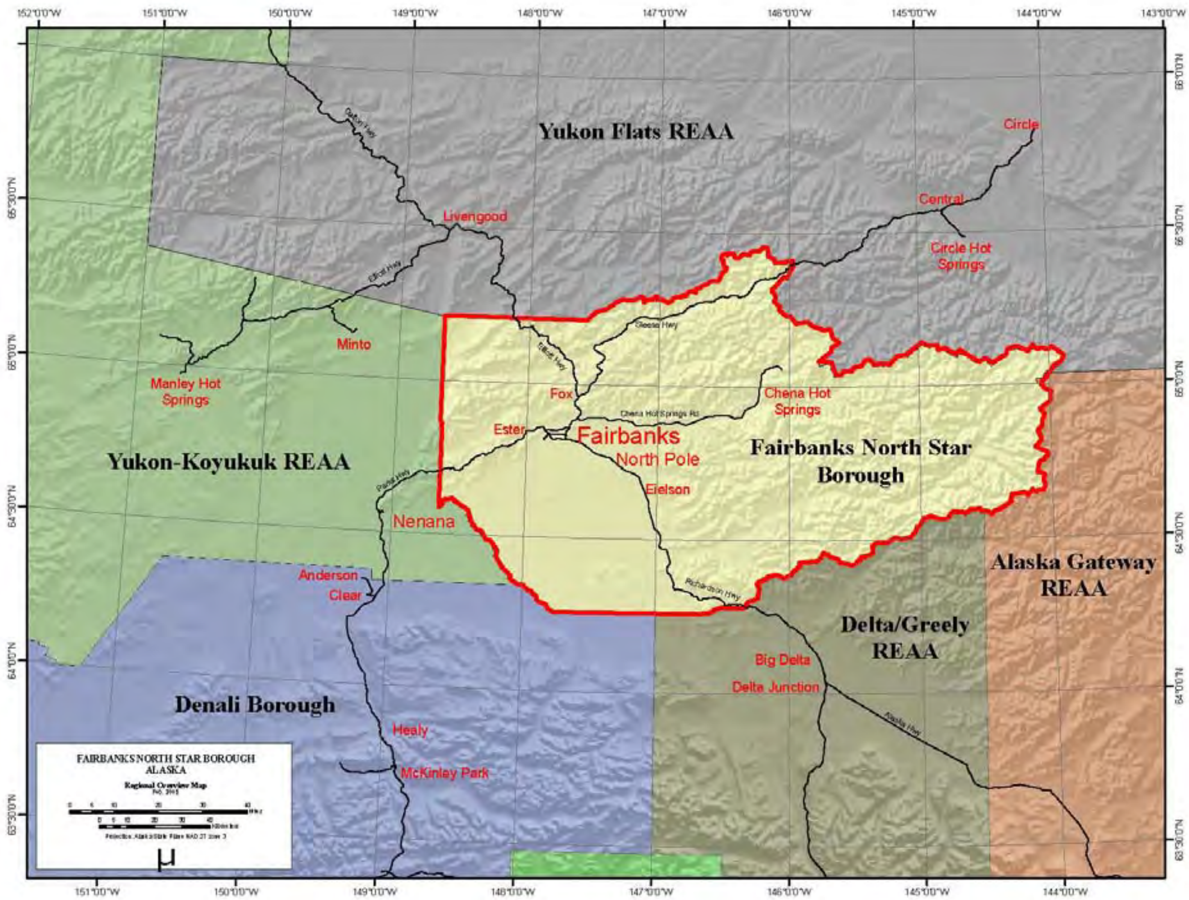


Figure 3 - City Boundaries within the Fairbanks North Star Borough

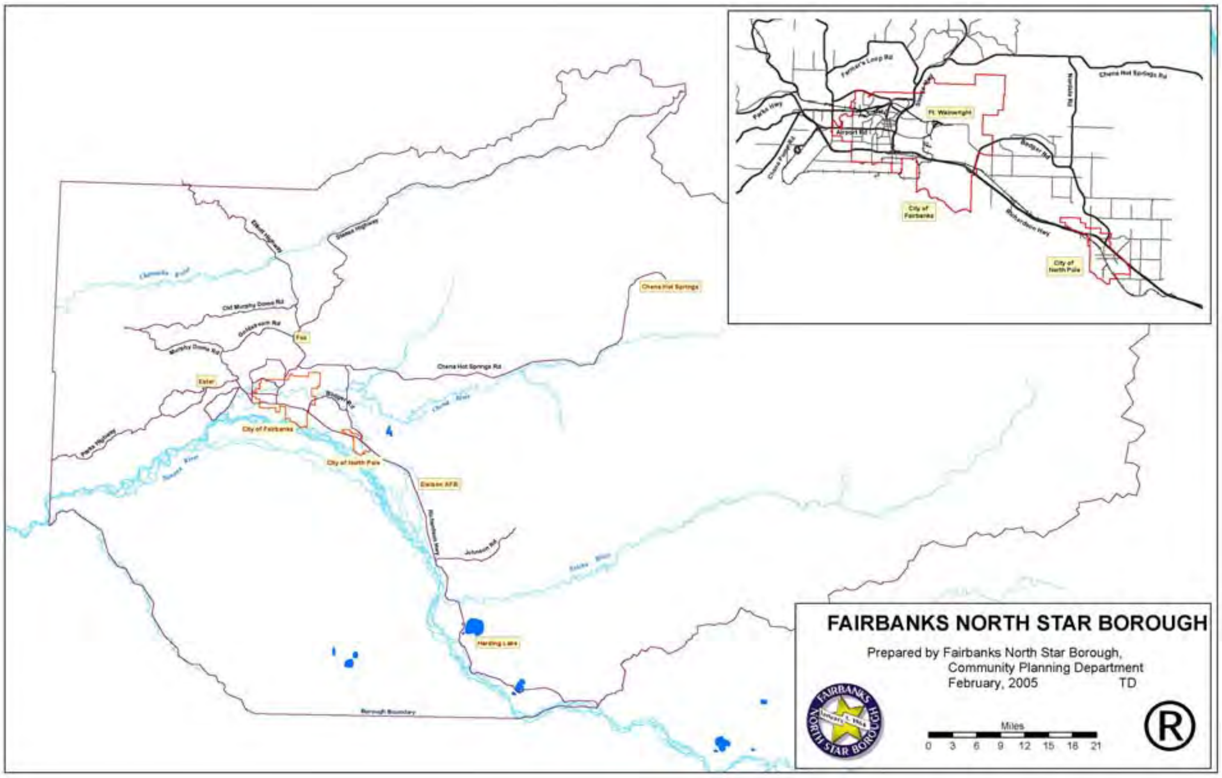
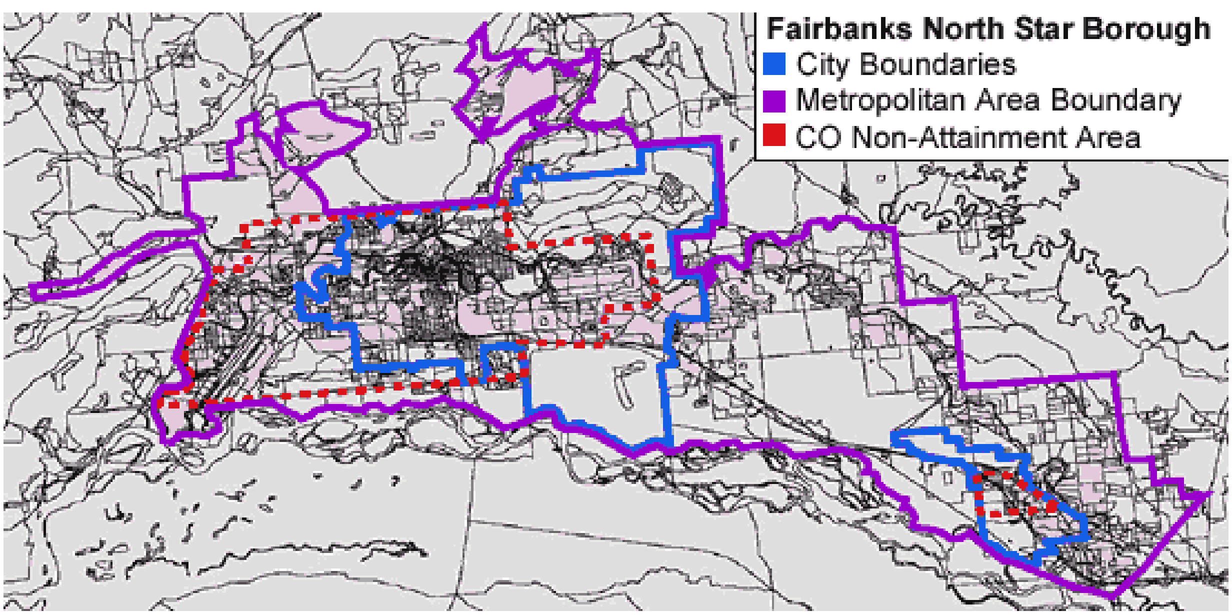


Figure 4 – FMATS Boundary



Population Density and Degree of Urbanization

The Fairbanks North Star Borough 2006 population as certified by the U.S. Census Bureau was 94,803 people and it is the second largest community in the state. Much of the Borough's population is concentrated in the urban area in and around the city of Fairbanks. A less densely urbanized area extends 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).

Air Quality and Sources of $PM_{2.5}$ Emissions

Ambient air monitoring conducted in downtown Fairbanks coupled with efforts by the department and the Fairbanks North Star Borough to characterize possible sources of $PM_{2.5}$ have identified a number of potential causes of high concentrations within the community. Much work remains to more fully understand the extent of the problem area and the sources of concern. The information provided in this section serves as a starting point for further efforts on source characterization.

In a recent study by the Fairbanks North Star Borough's contractor, Sierra Research, positive matrix factorization (PMF[6,7]) was used to analyze the co-variance in air quality measurements in Fairbanks in an attempt to discern the number and types of contributing sources.[8] PMF is a tool for looking at speciated air quality data to attribute source categories; however, its accuracy and effectiveness at attributing data under Fairbanks winter conditions is not fully known. Nonetheless, it can provide some initial insight into sources contributing to $PM_{2.5}$ concentrations at the Fairbanks downtown monitoring site.

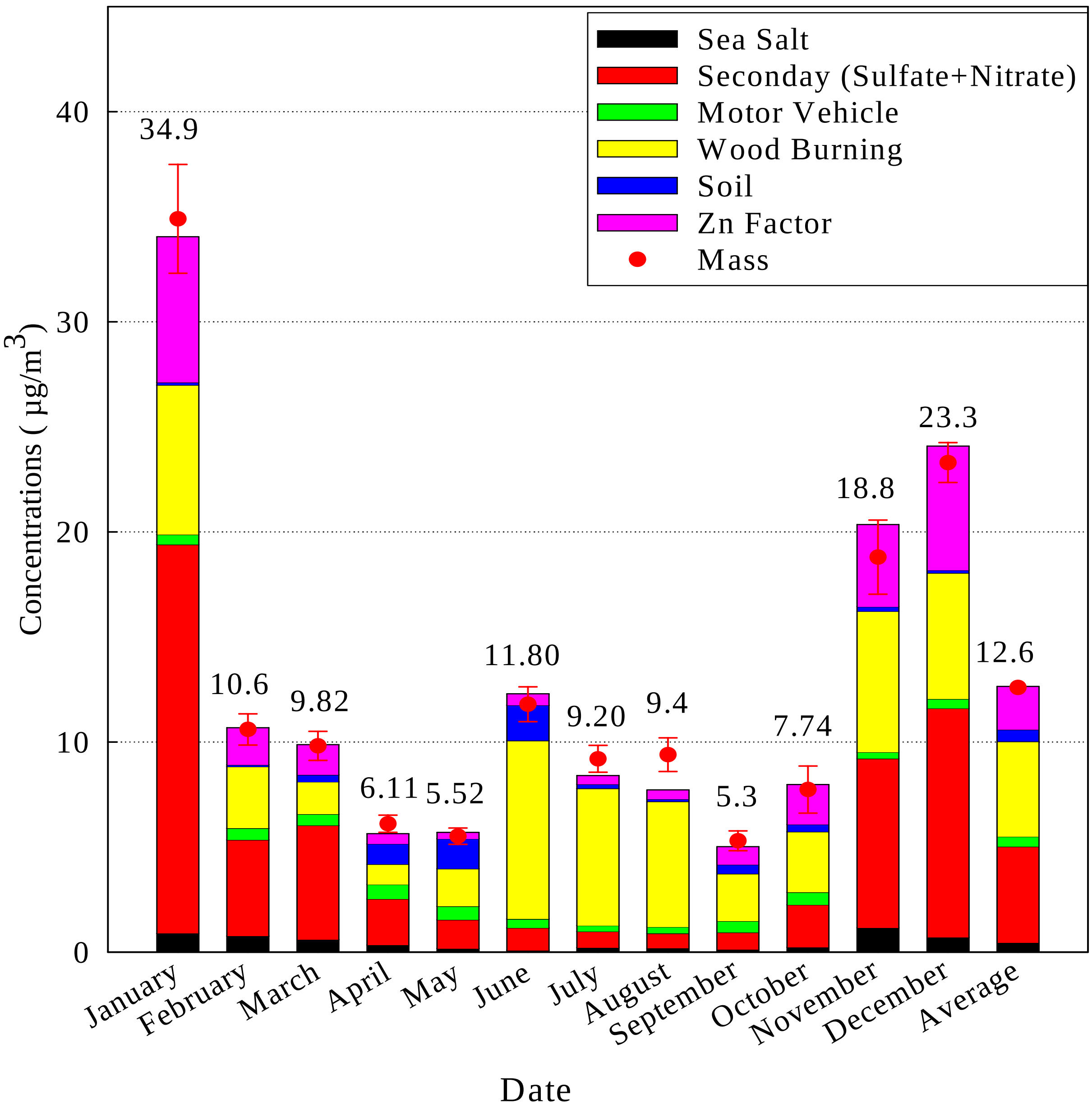
The study found that in winter months, secondary aerosol, which is primarily sulfate and nitrate, makes up about 40-55% of the monthly average mass concentrations of $PM_{2.5}$, with the highest percentage in January (the coldest month, with an average temperature of about -10ºF). Most of the remaining aerosol mass, by this accounting, is contributed about equally by wood burning and an unknown zinc-related factor, with smaller contributions found for sea salt, motor vehicles, and soil (in that order). These results are summarized in Figure 5 (see reference 11 for additional details).

One major uncertainty in the aforementioned Fairbanks PMF analysis is that the source of the zinc factor is unknown. Possible sources include burning of waste lubricating oil in and around Fairbanks, burning of lubricating oil by motor vehicles, other local trace sources, or distant sources of zinc mining and ore handling.[9,10] Zinc is widely used as an additive in lubricating oils for Diesel engines and, in lower concentrations, for gasoline-powered engines in motor vehicles and other machines.[11] Cahill has shown[12] that "Diesels and smoking cars have robust metallic tracers (Zn, P) in the very fine, ultra fine, and nano-particle modes from burned lubricating oil." If, in fact, the zinc-related factor is due to motor vehicles, the motor vehicle contribution to $PM_{2.5}$ would be much greater than shown above from the PMF analysis.

Another uncertainty about the aforementioned analysis is whether the monthly average accurately reflects conditions during the worst-case 24-hour period that may correspond to a

$PM_{2.5}$ design day. For example, the inventory of space heating sources, including both the burning of both wood and of sulfur-bearing fuel oil, is expected to be significantly higher on the coldest day(s) compared to average winter days or even to average January days. Furthermore, atmospheric conditions may be quite different on the coldest days, which are likely to include episodes of "ice fog,"[5] very restricted vertical mixing, and little or no wind.

Figure 5
Source Contributions to Total $PM_{2.5}$ in Fairbanks
(03/17/2005~01/15/2007)



Sulfates

In winter, levels of $PM_{2.5}$ in Fairbanks are correlated inversely with temperature, as shown in Figure 6. The correlation, while statistically significant, is rather weak ($r^2 = 0.28$) and is complicated by the fact that at least two factors are confounded. First, a likely source of the sulfur dioxide emissions and atmospheric sulfate is fuel burning for space heating, which increases as temperature decreases. But in addition, atmospheric dispersion decreases with temperature due to lower wind speeds, lower mixing depths, and more extreme lapse rates (which further retard vertical mixing). Ice fog may present an additional complication. The net effect of all these factors, as shown in Figure 6, is that the daily average $PM_{2.5}$ concentration increases by about 4μg/m^3 for each 10 degree drop in temperature. Furthermore, as shown in Figure 7, $PM_{2.5}$ and sulfate concentrations are highly correlated ($r^2 = 0.85$). In contrast to sulfates, nitrates are much more weakly correlated with $PM_{2.5}$ ($r^2 = 0.38$, as shown in Figure 8).

Figure 6
$PM_{2.5}$ vs Temperature

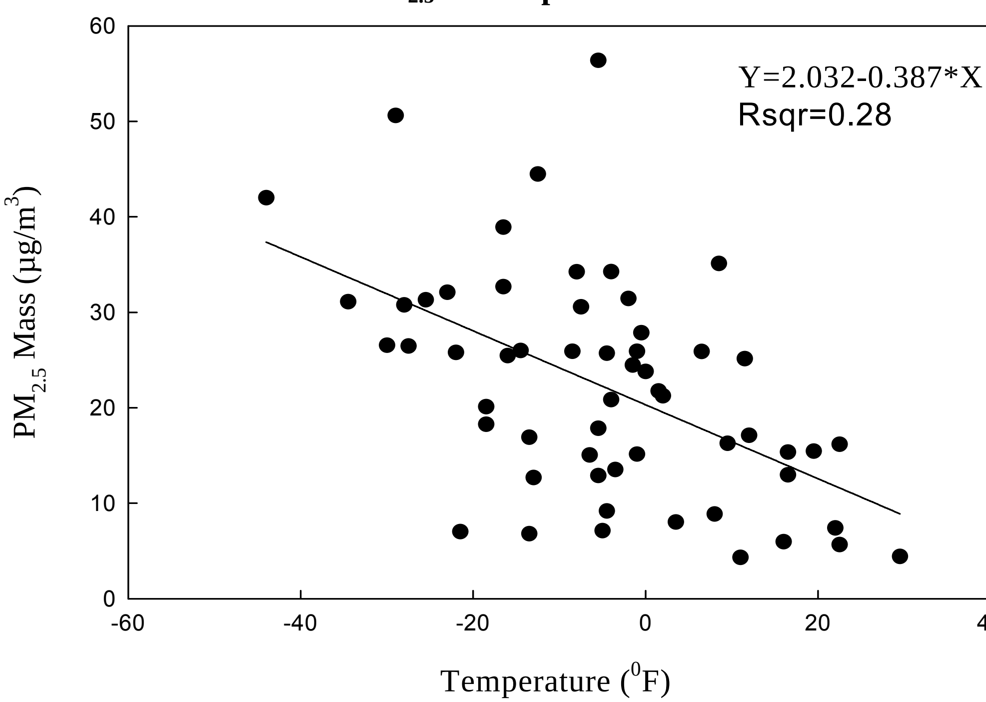


Figure 7
PM$_{2.5}$ Mass vs Sulfate Mass

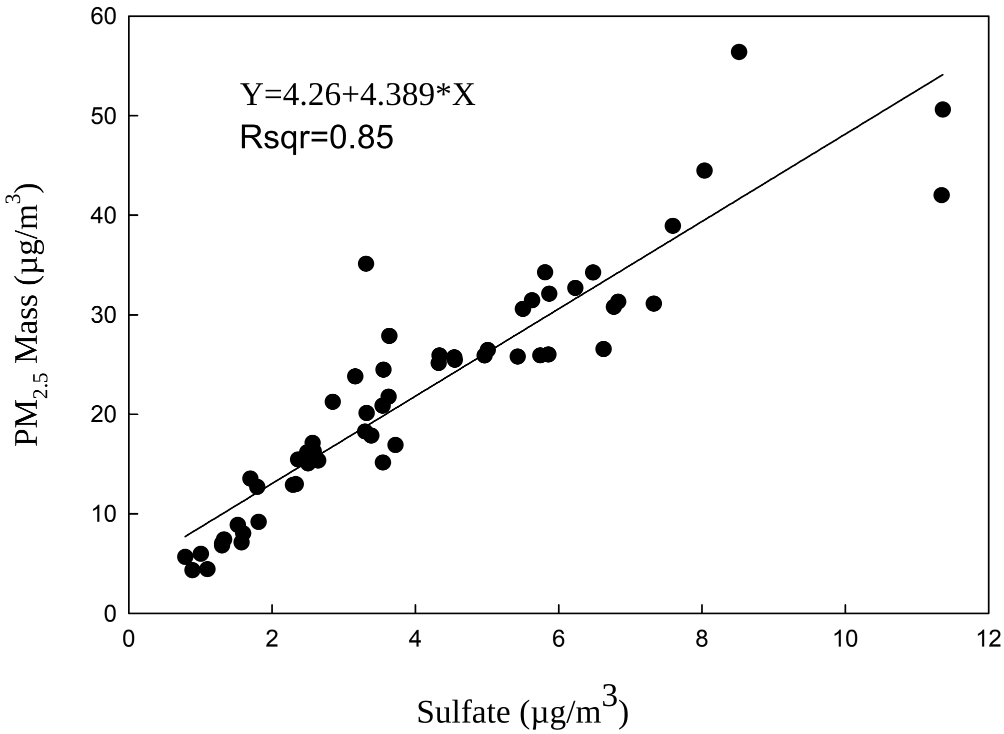
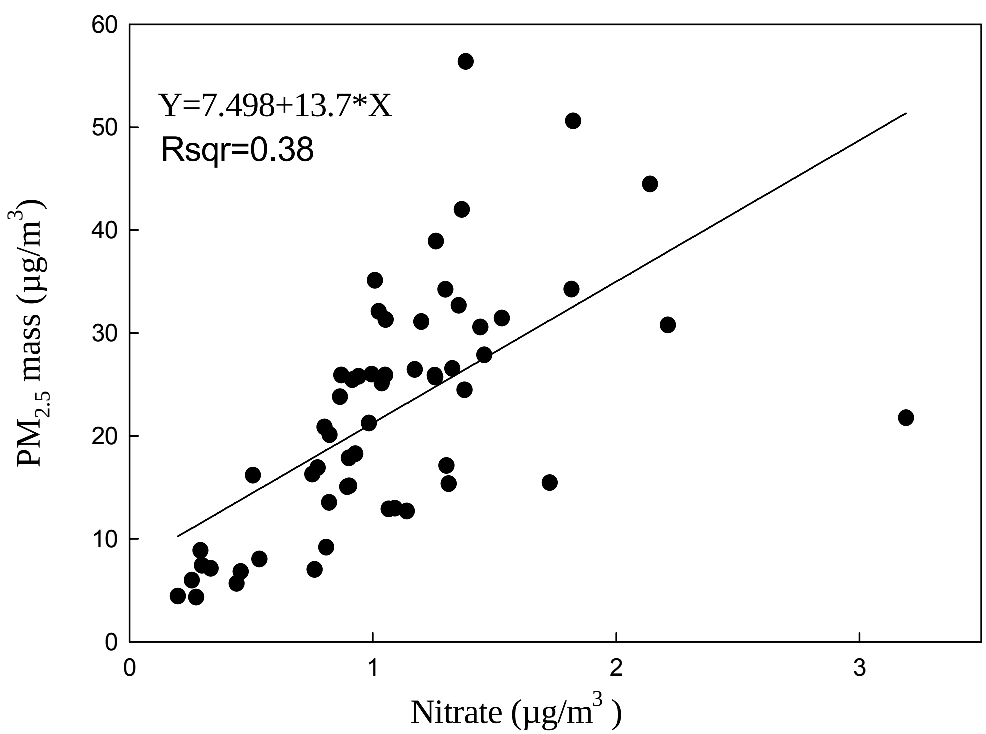


Figure 8
PM$_{2.5}$ Mass vs Nitrate Mass



Fuel Burning

Although there is a multiplicity of sources in Fairbanks that burn fuel containing sulfur, it is possible that the distillate fuel used in space heating could be a dominant source of sulfur oxide emissions and atmospheric sulfates in Fairbanks in the winter. This conclusion follows from consideration of the inventory of fuel used, which is summarized for a recent year in Table 1 (attached)*, and knowledge of the fuel sulfur contents.

Significant amounts of gasoline and Diesel fuel are burned in mobile sources in Fairbanks, but the sulfur content of both of these fuels has been reduced dramatically in recent years, due to strict environmental regulation, to respective levels of about 0.007% and 0.08% sulfur by weight. The sulfur content of distillate oil that is used for home heating has not been so regulated, and remains at about 0.22 weight percent sulfur, resulting in about 600 tons per year of sulfur dioxide emissions. The vast majority of these emissions occur during the winter months, and the annual level is roughly six times greater than the summed SO_2 emissions contribution from the combustion of gasoline and Diesel fuel used in the mobiles source sector (estimated at 95 tons for calendar year 2002). By comparison, point sources in the Borough (some of which are elevated well above typical ground-based mixing heights) emit about 2500 tons of SO_2 per year. Of this 2500 tons, the coal-fired power plants in Fairbanks emit an estimated 828 tons per year and the Golden Valley Electric Association (GVEA) power plant in North Pole is estimated to emit about 1578 tons per year.

The contribution to SO_2 emissions from coal-burning in and around Fairbanks and from the combustion of distillate fuel oil for reasons other than space heating in North Pole and elsewhere is significant. However, emissions from the Aurora Energy Chena and Fort Wainwright coal-fired power plants are generally expected to have an effective plume height that is well above the surface-based mixed layer under conditions of cold temperature. The other distillate fuel sources are generally much more distant from the downtown air monitoring site (the GVEA power plant in North Pole is about 14 miles SE of the downtown Fairbanks air monitor). While both of these sources could potentially be important contributors to regional sulfate, the most likely local source appears to be the very large amount of fuel that is burned to heat individual homes and buildings in and around Fairbanks. These local space heating emissions as well as those from diesel vehicles are released into or very close to the boundary of the semi-permanent surface-based mixed layer. An important countervailing consideration is that many commercial buildings in the downtown area (generally to the north of the monitoring site) are heated by hot water from the Aurora Energy power plant.

Refinement of several of these assumptions will require updated fuel use information and a detailed calculation of temperature-dependent SOx emissions. Ideally, it would also include dispersion modeling predictions for the major point sources in the region and a detailed measurement survey of $PM_{2.5}$ concentrations both within and well outside of Fairbanks during the winter.

*The fuel use estimates are partly based on assumptions and should be considered rough estimates only.

Wood Burning

A recent investigation into possible increases in wood-burning in and around Fairbanks in recent years found the following[13]:

> *Residential heating oil prices in Alaska increased significantly in each of the last four years, and data from DEC-sponsored home heating surveys in 2006 and 2007 show that more households have installed wood-burning appliances. The same two-year survey data do not show a statistically significant change in the amount of wood burned per household (the average cords burned per household actually decreased in the respective surveys from 3.22 to 2.82). However, there is suggestive evidence that wood burning may have increased between 2004 and 2005, and then stabilized in 2006.*

Another important source of wood burning emissions in and around Fairbanks is external or outdoor wood boilers (OWBs). Such OWBs are believed to be relatively few (but increasing) in number in Fairbanks and are believed to have rather severe but generally localized impacts, as suggested by a recent NESCAUM assessment[14,15] (mostly in the lower 48 states) and confirmed by a recent pilot $PM_{2.5}$ survey in Fairbanks.[16]

If a major effort were to be made in the future to restrict the installation or use of wood-burning appliances in Fairbanks in order to improve air quality, much more information would first be needed to quantify their contribution to emissions and $PM_{2.5}$ concentrations on critical high-$PM_{2.5}$ days. Investigators have used a variety of methods to measure and try to distinguish wood combustion $PM_{2.5}$ from that caused by other sources. Ionic (water soluble) potassium is one chemical marker used for wood smoke, and another is elemental potassium[17]. More recently, several investigators have used or are currently testing the use of a two-wavelength aethalometer to distinguish wood smoke in Rutland, Vermont,[18,19] Connecticut,[20] and in Seattle, Washington[21]; results have been promising but further confirmatory work is reportedly needed. The use of levoglucosan, a pyrolysis product of cellulose has been tested as a tracer of wood smoke, but results have been uncertain.[22]

Mobile Sources

A recent review of source contributions for Fairbanks[11] provided some initial insights regarding the significance of motor vehicle $PM_{2.5}$ and precursor emissions as outlined below. As with other source categories, there remains a need to further characterize contributions from gasoline and diesel on-road and non-road mobile sources.

- Diurnal Trends – These trends show that the a.m., p.m., and midday travel peaks are not discernable in the hourly trends in concentrations observed on days when the standard was exceeded. Particularly surprising is that the impact of the morning traffic peak is barely discernable in the PM data.

- Correlation Analysis – This analysis does not directly address motor vehicles, but suggests that nitrate and therefore NOx precursor emissions (of which motor vehicles are a significant source) are not significant. It also shows that organic carbon (OC) is highly correlated with $PM_{2.5}$ mass, but provides no insight into the contribution of motor vehicles to OC.* CO is shown to have a relatively high correlation (r^2=0.51) with $PM_{2.5}$, which suggests that motor vehicles, which are a significant source of CO, could be a contributor to $PM_{2.5}$. An alternate interpretation could be that as temperature declines, the production of $PM_{2.5}$ from other sources is increased in such a manner that it is roughly proportional to the increase in CO production from motor vehicles.† In other words, the same meteorological conditions that cause an increase in $PM_{2.5}$ concentrations can cause an increase in CO concentrations, even though the primary sources of these pollutants may be different.

- PMF Analysis – The interpretation of PMF factors is somewhat subjective, however, motor vehicles as a source are shown to have a very limited contribution to $PM_{2.5}$ mass and exhibit little seasonal variation‡. The motor vehicle contribution to secondary particulate, which is shown to be the most significant source, is unclear. While the contribution to sulfate appears to be limited,§ the contribution to OC could be significant. A review of the relative amount of gallons of fuel consumed on a typical winter day shows that space heating consumes roughly 104,500 gallons of fuel oil. Motor vehicles are estimated to consume 18,650 gallons of Diesel fuel and 104,600 gallons of gasoline on an average winter day, and are suspected to be a significant contributor to OC.

- Emission Inventory – Motor vehicles are responsible for 56% of the corrected inventory of directly emitted $PM_{2.5}$ emissions in 2005 and 26% in 2018. Their share of the inventory in 2005 is almost double the level emitted by wood burning stoves, which PMF has identified as the second most significant source after secondary pollutants. Their share of NOx emissions is high, but nitrates are not a significant contributor to $PM_{2.5}$. Their share of SOx emissions is low in 2005 and essentially disappears after 2006.

Overall, the available data are not conclusive with regard to the significance of motor vehicles' contribution to $PM_{2.5}$ concentrations measured in downtown Fairbanks. Several of the data

* A review of MOBILE6.2 national average PM emission estimates for calendar year 2005 shows that the model does not differentiate exhaust species for light-duty vehicles, but does for heavy-duty vehicles. Total exhaust for light-duty vehicles is estimated to be 0.0056 g/mi. Heavy-duty vehicles are estimated to produce 0.0163 g/mi elemental carbon (EC) and 0.0083 g/mi organic carbon (OC). A review of the literature shows that over 50% of gasoline exhaust is OC and 24% is EC. When weighted for travel (82% gasoline, 18% Diesel), gasoline vehicles are estimated to be responsible for roughly 60% of the directly emitted OC.

† The interpretation of correlations in air pollutant concentrations, including the correlations cited herein, entails some risk. In general, correlation does not prove causality and, for the case at hand, correlations in pollutant concentrations could be caused in large part by emissions from several types of unrelated sources all being affected in a substantially similar way by changes in meteorology.

‡ An important caution here is that the interpretation of PMF factors is somewhat subjective. The factor that is described as "motor vehicle" may be most representative of gasoline-powered motor vehicles while at the same time including some elements from other sources. Similarly, the "Zn factor" may contain some contribution from Diesel-powered motor vehicles and other sources (although the large contribution to Zinc variance is unexplained).

§ It is possible to rule out motor vehicles as a significant source of sulfate, because of the recent phase-in of low sulfur Diesel fuel (last October) and low sulfur gasoline (last January). Since the actual phase-in of both fuels occurred well before the mandated implementation date, it is clear that motor vehicles were not a significant contributor to sulfate levels produced during this past winter. Nevertheless, high concentrations of $PM_{2.5}$ were recorded this past winter.

sources suggest that directly emitted and precursor emissions from motor vehicles may not be significant, including those explained below.

- PMF analysis (if correct) shows motor vehicles to be a consistently low contributor in both summer and winter months.
- Sulfate was found to be highly correlated with $PM_{2.5}$ mass. Implementation of low sulfur gasoline (January 2006) and Diesel fuels (October 2006) essentially eliminated on-road motor vehicle sulfate production during 2007. Nevertheless, Fairbanks continued to exceed the ambient $PM_{2.5}$ standard after the introduction of these low sulfur fuels. ,
- The impact of motor vehicle peak travel activity is not directly observable in the diurnal measurements of $PM_{2.5}$ concentrations.

In contrast, several findings suggest motor vehicles may be a significant contributor to $PM_{2.5}$ concentrations:

- The emission inventory estimate suggests that motor vehicles are responsible for roughly double the level of $PM_{2.5}$ emitted by wood burning and the PMF analysis identified wood burning as the second largest $PM_{2.5}$ source.
- Analysis of winter fuel consumption suggests that motor vehicles are a significant source of organic carbon (OC) emissions and OC is found to be highly correlated with $PM_{2.5}$ mass.
- A recent PMF study in the Midwest found that mobile as well as industrial sources were important to organic compound concentrations, and this was true with respect to all nine sites examined.[23]

These results tend to be consistent, at least qualitatively, with those reported earlier from dynamometer-based emissions study in Fairbanks.[24]

Because several of the above points could be debated, the most prudent conclusion is that additional data are needed to assess whether motor vehicles are a significant contributor to winter $PM_{2.5}$ concentrations in Fairbanks.

Critical Knowledge Gaps

There remain some key questions and knowledge gaps in understanding the magnitude, causes, and potential solutions to the problem of elevated $PM_{2.5}$ concentrations in and around Fairbanks. Further data and information would be helpful in better defining the spatial extent of the $PM_{2.5}$ problem area as well as in understanding the relative source contributions. Areas that need to be addressed include determining:

- the spatial extent of the high $PM_{2.5}$ concentrations in the vicinity of Fairbanks. With air quality measurements at only one multi-year monitoring site, it is difficult to verify the actual size of the problem area. Additional monitoring could help to verify the proposed boundary for the non-attainment area.

- the principle source of SO_2 emissions and elevated secondary sulfate concentration during poor air episodes (space heating, aircraft, industrial facilities).
- the principal source(s) of the PMF zinc-factor (lube oil emitted from motor vehicles, waste oil burning, distant mining and zinc-handling operations, other).
- whether local or regional coal-burning is a significant contributor to $PM_{2.5}$ at the downtown monitoring site or elsewhere in the Fairbanks area.
- whether motor vehicles are important contributors to $PM_{2.5}$ during episodes.
- the impact from outside wood boilers.
- how cold temperatures interact with emissions from space heating, motor vehicles (Diesel and gas), and residential wood burning.
- at what rate sulfates are formed and removed from the atmosphere under conditions found in Fairbanks.
- how well the $PM_{2.5}$ sampling apparatus perform in cold temperatures.

Over time, as more information about the air quality and sources in the vicinity of Fairbanks is developed, a more refined understanding of the spatial distribution and contributing source impacts will be acquired.

Air Quality and Emission Source Summary

Fairbanks winters are dominated by a pattern of cold, stable air that is conducive to the buildup of air pollutants.[25,26] This condition, together with local emissions of $PM_{2.5}$ and its precursors (especially sulfur dioxide), causes episodes of elevated $PM_{2.5}$ concentrations as monitored in downtown Fairbanks.

Based upon a positive matrix factorization (PMF) analysis of $PM_{2.5}$ speciation data collected at a site in downtown Fairbanks, the principal factors responsible for the elevated concentrations appear to be secondary aerosol (sulfate and nitrate), wood burning, and an unidentified zinc-related source profile. Motor vehicles seem to be less significant, but that conclusion somewhat contradicts information from other sources that show, for other locations, sharply increasing PM emissions from motor vehicles at lower temperatures. Consequently, the department is currently unable to reach any definitive conclusion about the relative contribution from various source categories.

Sulfate is much more important than nitrate in the secondary aerosol, and the presumed principal source is the combustion of sulfur-bearing fuel for space heating, which results in sulfur dioxide emissions. The secondary sulfate is assumed to be formed primarily in aqueous particles[*] into which the sulfur dioxide dissolves.[27] A small fraction (less than five percent) of the combustion-

[*] Under all but the coldest conditions (below about -22º F) in Fairbanks winters, most aerosol water, including the water generated by the combustion of all hydrocarbon fuels, is expected to be present as a liquid or supercooled liquid rather than being frozen and, as a result, is available to serve as a sink for atmospheric sulfur dioxide and as a site for the heterogeneous chemical reactions that produce sulfate. Below this temperature, ice fog begins to form, and at temperatures below about -40ºF, essentially no liquid water will be present stably in the atmosphere.

generated sulfur oxides emitted from fuel burning sources may also be directly emitted as sulfate.

Sources of wood burning emissions in Fairbanks include residential wood stoves and other appliances, and external wood boilers. Survey data and other evidence suggest that wood burning has increased in recent years. External wood boilers are a relatively new and substantially uncontrolled $PM_{2.5}$ source that has the potential to cause high localized concentrations of $PM_{2.5}$ and thereby be a significant air pollution nuisance as well as a potential health threat to nearby neighbors. There are a variety of methods for measuring $PM_{2.5}$ emissions from wood burning, including new methods that have a degree of selectivity for wood smoke.

Population and Traffic Growth Rates and Patterns

Fairbanks was established in the early 1900s as a trading post serving gold prospectors in the area. During the first part of the century, the population peaked and waned according to the price and availability of gold. Completion of the Alaska Highway in the 1940s, plus increased military activity in the area due to World War II, combined to cause considerable growth. By 1950, the population of the Fairbanks Census District (an area somewhat larger than the current boundaries of the Fairbanks North Star Borough) had grown to 19,409.

Continued military spending and increased governmental growth resulted in renewed economic activity and growth in population during the 1950s. By 1960, the population of the Fairbanks Census District had risen to 43,412. In the 1960s, military influence in the area leveled off, while increased oil exploration on the North Slope accounted for a 15% increase in population during the decade. The Fairbanks North Star Borough was formed in the mid-1960s. The 1970 Census District population of 50,043 can be compared to a Borough population for the same year of 45,864.

Construction of the Trans-Alaska Oil Pipeline during the 1970s resulted in a large population influx into the area. Fairbanks North Star Borough population peaked at 72,037 in 1976. With completion of the pipeline, the population fell dramatically to 51,659 in 1981. However, increased state and local governmental spending due to state oil revenues led to a resurgence in local economic activity and another growth spurt in population, resulting in a 1985 Borough population of 75,079.

Since 1985, population levels in the Fairbanks area have remained relatively unchanged. Increase in military activity due to the addition of a light infantry division to Fort Wainwright acted to offset a reduction in state and local governmental spending due to declining oil revenues. These factors resulted in a 1990 Borough population of 77,720. According to the Census,[28] the Borough population experienced little change between 1990 and 2000, with an overall growth rate of 0.6% per year. During that same time period, the Census data indicate that the population within the cities of Fairbanks and North Pole actually declined from 39,858 to 39,231, a reduction of 0.16% per year. The decline in population during the 1990s is displayed in Figure 9. It shows that while there was a small net reduction in population, the year-to-year change was very modest.

Population forecasts for the 2005-2015 period show an increase of about 3% between 2005 and 2006 then a steady increase of about 1% each year to 2015. The population forecast for the carbon monoxide nonattainment area as projected in the 2025 Fairbanks Metropolitan Area Transportation System (FMATS) Long Range Transportation Plan (LRTP)[29] is shown in Table 2. The vehicle travel-specific forecasts for the period are described in more detail below.

Growth in Vehicle Travel

Despite the slight reduction in population recorded between 1990 and 2000, Fairbanks and North Pole still experienced a modest increase in travel during this decade. The increase is based on traffic counts recorded at Highway Performance Monitoring System (HPMS) and other sites located throughout the Borough.[30] Figure 10 shows that travel activity, measured by average daily traffic counts, increased from 665,398 miles per day in 1990 to 752,992 miles per day in 2001, a growth rate of 1.1% per year.

Figure 9

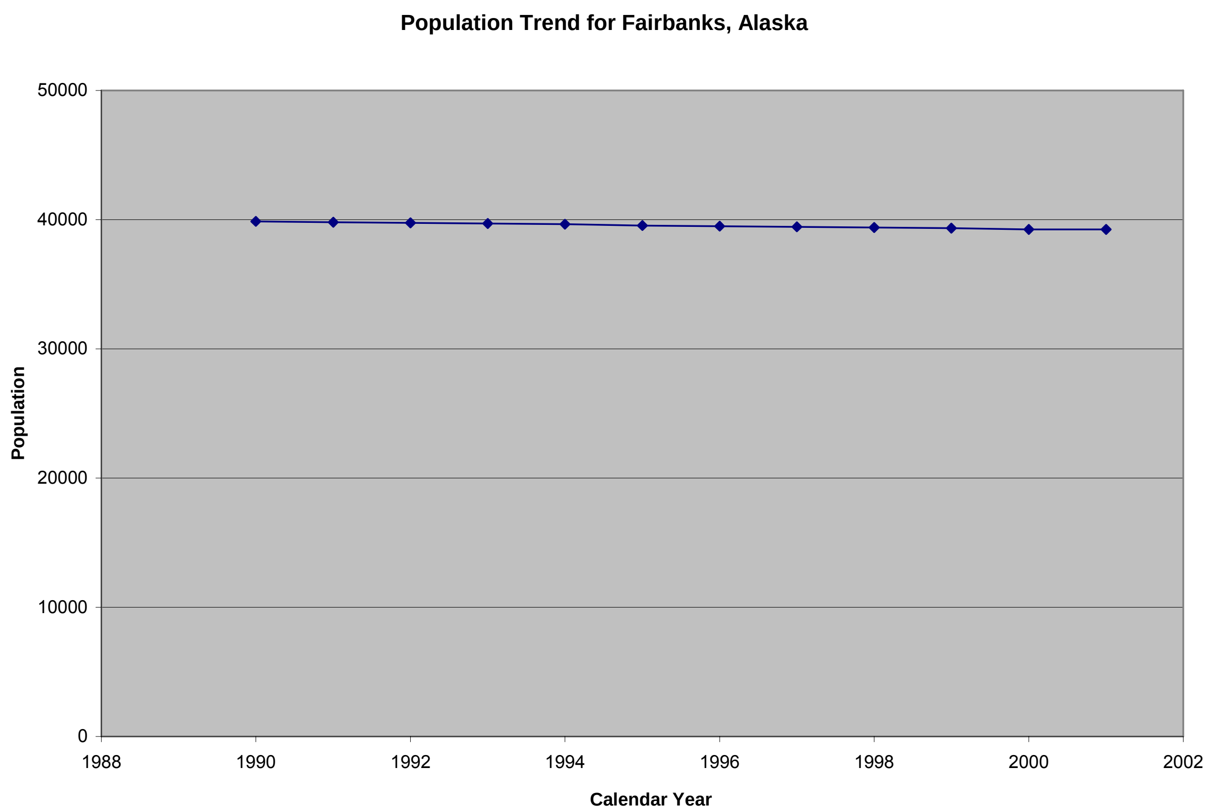


Figure 10

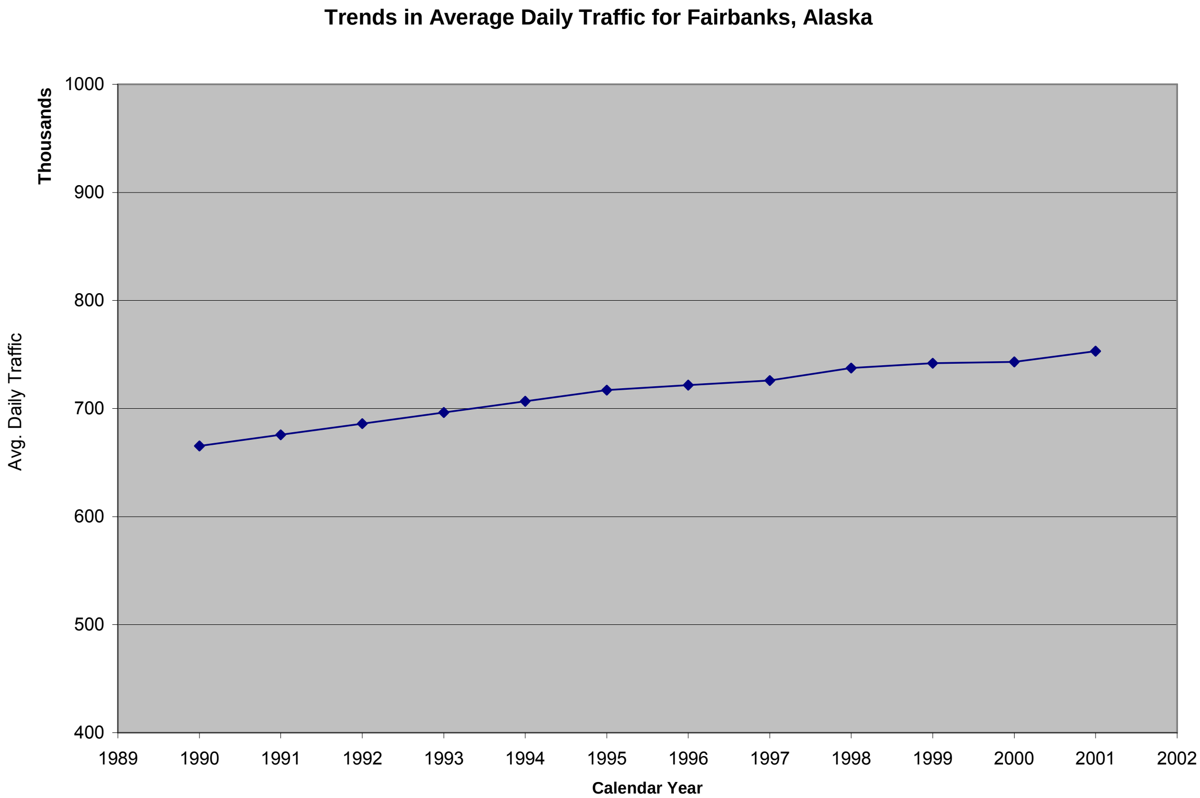


Table 2
Projected Fairbanks & North Pole Population

Calendar Year	LRTP Population Forecast
2005	41,183
2006	42,445
2007	42,809
2008	43,178
2009	43,553
2010	43,933
2011	44,320
2012	44,712
2013	45,111
2014	45,516
2015	45,926

From 2002 through 2004, ADOT&PF reported an annual VMT growth rate of 1.2% for Fairbanks and North Pole. Starting in 2005, the projected growth in vehicle travel reported in the area's current CO Maintenance Plan was updated using the VMT projections reported in the FMATS LRTP. The resulting annual VMT projections for the area during the 2005-2015 CO maintenance planning period are shown in Table 3. While the Fairbanks CO maintenance area boundary differs from that of the proposed $PM_{2.5}$ non-attainment area, these projections provide a basis for the VMT growth anticipated in the Fairbanks area.

Table 3
Projected Vehicle Travel in the Fairbanks CO Maintenance Area (2005-2015)

Year	Vehicle Miles Traveled (per winter day)
2005	816,616
2006	862,743
2007	876,029
2008	889,519
2009	903,217
2010	917,126
2011	931,249
2012	945,590
2013	960,151
2014	974,937
2015	989,950

With a relatively stable population and slow growth in VMT, the FMATS transportation network has relatively low levels of congestion and excess transportation capacity. FMATS routinely considers and implements projects that will assist in reducing congestion such as signalization improvements at intersections. The Fairbanks North Star Borough also has a transit system that provides a good level of service for a relatively spread out community.

Existing Control of Emission Sources

While no Fairbanks area sources have been specifically targeted for control of fine particulates at this time, there are some existing controls in place:

- Major stationary sources are controlled through the Alaska Department of Environmental Conservation's permitting program. With regard to particulate matter, it should be noted that the coal-fired power plants in Fairbanks are controlled with bag houses.
- Mobile sources are controlled by federal fuel and emission rules that limit particulate matter and pre-cursor pollutants. It is not known how effective these controls are at the extreme cold temperatures found in Fairbanks, but improvements should continue to be made as the vehicle fleet turns over.
- Fairbanks has an extensive network of electrical plug-ins powered at 20° F that allow citizens to use engine block heaters to keep their motor vehicle engines warm during cold temperatures. This program significantly reduces CO emissions from cold starting vehicles, but it is not known how much benefit may exist for fine particulate emissions from the use of engine pre-heating.

- The Fairbanks North Star Borough operates a transit program that provides some benefits through reduced VMT from mobile sources.
- A local wood burning control program exists under the carbon monoxide maintenance plan. To the extent that high $PM_{2.5}$ days occur on days with high CO concentrations, this control program could provide some benefit. It is more likely that a different program will be needed to fully address $PM_{2.5}$ emissions from wood-burning stoves.
- Open burning is prohibited from November 1 through the end of February within the areas of the Borough designated as Urban, Urban preferred commercial, Light or Heavy Industrial, or Perimeter area, with camp fires being an exception.
- Prescribed fire for burns over 40 acres is managed by the Alaska Department of Environmental Conservation through a permitting process and a smoke management plan.

Conclusion

The non-attainment boundary proposed by the State of Alaska encompasses the portion of the Fairbanks North Star Borough airshed likely to be violating the fine particulate matter health standard. The air quality speciation data suggest a number of potential contributing sources all tied to population activities in the urban area. The boundary is based primarily on the topography of the airshed coupled with insight from the existing monitoring data from downtown Fairbanks on sources and chemical indicator species of concern. Because there is only one monitoring site in Fairbanks, the monitoring data and source characterization work derived from that site is most likely not representative of the source contributions thoughout the entire area.

It is possible that this boundary will need to be altered based on new data. At this time, no monitoring data exists for the city of North Pole or other residential areas in the outlying valleys to the north of Fairbanks. New monitoring data and better understanding of emission sources could lead to a larger or smaller non-attainment area boundary. If new monitoring data shows concentrations in excess of the standard in North Pole, or other outlying populated areas, or sources from North Pole are implicated in violations in Fairbanks, a revision to the proposed boundary would certainly be warranted. At this time, there is insufficient information to suggest that North Pole or these other outlying populated areas have an air quality problem or are significantly contributing to the air quality violations occurring in downtown Fairbanks. For this reason, they have been excluded from the proposed boundary.

Table 1
Annual Fuel Use in Fairbanks by Source Category in 2002
(not the nonattainment area)

Source	Subcategory	Gasoline (gallons)	Diesel (gallons)	Distillate (gallons)	Process Gas (gallons)	Process Gas (feet3)	JP4 (gallons)	Aviation Gasoline (gallons)	LPG/ Propane (gallons)	Natural Gas (feet3)	CNG (gallons)	Coal (tons)	Wood (cords)	Daily Trips (trips/day)	Daily VMT (miles/day)
On-Road		**40,345,310**	**3,185,156**											**508,504**	**1,745,291**
Non-Road		**495,248**	**2,942,861**	**0**	**0**	**0**	**4,167,000**	**70,500**	**66,461**	**0**	**0**	**0**	**0**		
	Equipment	495,248	1,960,521						66,461		6,792,258				
	Rail		982,340												
	Aircraft						4,167,000	70,500							
Area				**19,311,033**						**300,000,000**			**2,737**		
Point		**0**	**80,603**	**43,446,679**	**42,410,066**	**173,000,000**	**0**	**0**	**67,926**	**0**	**0**	**438,887**			
	Flint Hills		80,603		42,410,066										
	Wainwright			113,000			78,000,000		67,926			207,465			
	Univ. of AK			1,407,811								54,783			
	GVEA NP			39,872,868											
	AK RR											2,918			
	Aurora											173,721			
	PetroStar			1,210,000		173,000,000									
	GVEA Zn			843,000											
TOTAL		**40,840,558**	**6,208,620**	**62,757,712**	**42,410,066**	**173,000,000**	**4,167,000**	**70,500**	**134,387**	**300,000,000**	**0**	**438,887**	**2,737**	**508,504**	**1,745,291**

Notes:

On-Road Diesel and Gasoline fuel use is conservatively estimated by assuming a VMT split of 95%/5% and a wintertime mpg of 15 for gasoline vehicles and 10 for Diesels x 365 days/year

Rail fuel use reported for 1999 (962,000 gallons) was adjusted at annualized growth rate of 0.7%/year to get the 2002 value

The aircraft fuel use values are based on estimates for representative aircraft during landing and take off operations at Fairbanks International and Fort Wainwright.

The point source values are based on information reported by each facility to the State.

Only a small portion of the 78 million gallons of JP4 listed by Fort Wainwright was consumed within Fairbanks.

An estimate of the actual fuel used within the Borough is listed in the Aircraft consumption estimate.

References

[1]. 40CFR Part 51, Clean Air Fine Particle Implementation Rule; Final Rule, April 25, 2007.

[2]. Met One, the manufacturer of the BAM 1020 Particulate Monitor, specifies an operating temperature range of the instrument down to 0ºC (32ºF) and an ambient temperature range (for the air sample) down to -30ºC (-22ºF). ("BAM 1020 Particulate Monitor Operation Manual", BAM-1020-9800 Rev F, Met One Instruments, Inc.) Instrument and sample ambient sample temperatures were at times lower than both of these limits for sampling prior to 2007 when Borough staff installed an environmental enclosure and an inline sample heater. Any measurements that were made under such conditions, absent the use of the environmental enclosure and in-line heater are subject to question. Measurements made after the installation of the in-line heater may, however, be subject to a negative artifact due to loss of VOC caused by the in-line heater (as described in the Met One operating manual) or by loss of volatile nitrate.

[3]. See, for example: "$PM_{2.5}$ in the Upper Midwest", Lake Michigan Air Director's Consortium, June 2, 2003: http://www.ladco.org/reports/PM25doc2xx-1_small.pdf

[4]. B.Hartman and G.Wendler, "Climatology of the Winter Surface Temperature Inversion in Fairbanks, Alaska," http://ams.confex.com/ams/pdfpapers/84504.pdf.

[5]. C.S. Benson, "Ice Fog, Low Temperature Air Pollution," Cold Regions Research and Engineering Laboratory, June 1970.

[6]. P. Hopke, "A Guide to Positive Matrix Factorization" (undated).

[7]. A. Reff et al, "Receptor Modeling of Ambient Particulate Matter Data Using Positive Matrix Factorization: Review of Existing Methods," <u>Journal of the Air and Waste Management Association</u>, 57:146-154, February 2007.

[8]. "Review and Source Contributions to Ambient $PM_{2.5}$ Concentrations," Sierra Research, 2007 (unpublished).

[9]. Zinc mining, refining and transport at the Red Dog Mine in western Alaska is a source of zinc dust (see for example: J.L. Clark , "Fugitive Dust Accumulation in Drifted Snow at the Red Dog Mine, Winter 2004- 2005, July 2005, teckcominco).

[10]. Other PMF analysis has shown factors that contain Zn (and other species) to be present at all sites in Alaska but concluded, due to lack of strong seasonal variations, that "local sources must be more important than distant sources" (A. Polissar *et al*, "Atmospheric Aerosol over Alaska, 2. Elemental Composition and Sources," <u>Journal of Geophysical Research</u>, 103, 19,045-19,057, 1998.)

[11]. See, for example, Wikipedia "Zinc dialkyldithiophosphate": "The main use of ZDDP is in anti-wear additives to lubricants (e.g. greases, motor oils). To date it is the dominant anti-wear agent, present in most machine and motor oils in amounts of about 1%. However for gasoline engine oil applications the amount of ZDDP has to be minimized; there is concern that zinc and phosphorus emissions could damage catalytic converters.")

[12]. T. Cahill, "Persistence of Very-fine, Ultra-fine, and Nano-particles in the Ambient Atmospheric Environment," University of California, Davis, available from: *http://www.cce.umn.edu/pdfs/cpe/conferences/nano/Thomas_Cahill.pdf*

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[13]. Memorandum to Alice Edwards, ADEC, from R. Dulla et al, "Fairbanks Home Heating Survey Update," May 2, 2007.

[14]. "Assessment of Outdoor Wood-fired Boilers," prepared by NESCAUM (the Northeast States for Coordinated Air Use Management), March, 2006.

[15]. P.R.S. Johnson, "In-Field Ambient Fine Particle Monitoring of an Outdoor Wood Boiler: Public Health Concerns," Journal of Human and Ecological Risk Assessment, (in-press), February 21, 2006.

[16]. F. Di Genova, *et al*, "Tier 2 Gasoline Benefits in Alaska; Phase 2: Preliminary Investigation of Particulate Matter Emission Sources in Fairbanks, Alaska with In-use Tier 2 Gasoline and Ultra Low Sulfur Diesel," Sierra Report No. SR2007-08-01, prepared for ADEC, August 2007.

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[18]. G. Allen, "Update on the Met One BAM: Cold, Warm, and Filter Media Issues," Air Quality Monitoring & Data Analysis National Conference (aka SAMWG), Point Clear, AL, May 13, 2004.

[19]. G. Allen, "Evaluation of a New Approach for Real Time Assessment of Wood Smoke PM": *www.nescaum.org/documents/2004-10-25-allen-realtime_woodsmoke_indicator_awma.pdf*

[20]. See: *http://www.dieselmidatlantic.org/calendar/events/presentations/ 2007_07MVRWC/ BabichMVRWC07.pdf*

[21]. M. Gilroy *et al*, "Urban Air Monitoring Strategy – Preliminary Results Using Aethalometer™ Carbon Measurements for the Seattle Metropolitan Area," Puget Sound Clean Air Agency, see: http://www.pscleanair.org/airq/Aeth-Final.pdf

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[23]. B. Buzcu-Guven, *et al* "Analysis and Apportionment of Organic Carbon and Fine Particulate Matter Sources at Multiple Sites in the Midwestern United States," Journal of the Air and Waste Management Association, 57:606-619, May 2007.

[24]. P. Mulawa, "Effect of Ambient Temperature and E-10 Fuel on Primary Exhaust Particulate Matter Emissions from Light Duty Vehicles," Environmental Science and Technology, 31:1302-1307, 1997.

[25]. B.Hartman and G.Wendler, "Climatology of the Winter Surface Temperature Inversion in Fairbanks, Alaska," http://ams.confex.com/ams/pdfpapers/84504.pdf.

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[27]. See, for example: J. H. Seinfeld, Atmospheric Chemistry and Physics, John Wiley and Sons, Inc., NY, 1998.

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[28]. Census data supplied by the Alaska Department of Transportation and Public Facilities (ADOT&PF).

[29]. LRTP report

[30]. "1997 – 1998 – 1999 Annual Traffic Volume Report," State of Alaska, Department of Transportation & Public Facilities.

Adopted

December 24, 2014

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April 14, 2003

Mr. David C. Miller, Division Administrator
Federal Highways Administration
P.O. Box 21648
Juneau, AK 99802-1648

Mr. Richard F. Krochalis, Regional Administrator
Federal Transit Administration
915 Second Avenue, Suite 3142
Seattle, WA 98174

Dear Mr. Miller and Mr. Krochalis:

In accordance with 23 CFR 450.306 and in cooperation with the Fairbanks North Star Borough, City of Fairbanks, and City of North Pole, I hereby designate the Fairbanks Metropolitan Area Transportation System (FMATS) Policy Committee as the Metropolitan Planning Organization (MPO) and cooperative decision-making body for the newly urbanized area of Fairbanks and North Pole as outlined in the enclosed FMATS Metropolitan Planning Area boundary map.

Also enclosed is a copy of the FMATS Inter-Governmental Operating Agreement and Memorandum of Understanding for Transportation and Air Quality Planning.

This agreement outlines the structure and process for developing transportation plans and programs for this urbanized area.

Sincerely yours,

Frank H. Murkowski
Governor

Enclosures

cc: Mike Barton, commissioner, DOT&PF
Ralph Swarthout, chair FMATS Policy Committee
Rhonda Boyles, mayor, Fairbanks North Star Borough
Steve Thompson, mayor, City of Fairbanks
Jeff Jacobson, mayor, City of North Pole

FAIRBANKS METROPOLITAN AREA TRANSPORTATION SYSTEM

Inter-Governmental Operating Agreement and Memorandum of Understanding for Transportation and Air Quality Planning

Fairbanks North Star Borough,
City of Fairbanks,
City of North Pole,
and
State of Alaska

FAIRBANKS METROPOLITAN AREA TRANSPORTATION SYSTEM

INTER-GOVERNMENTAL OPERATING AGREEMENT and MEMORANDUM OF UNDERSTANDING for TRANSPORTATION AND AIR QUALITY PLANNING

In The Metropolitan Area of the Fairbanks Metropolitan Planning Organization

Fairbanks North Star Borough,
City of Fairbanks,
City of North Pole,
and
State of Alaska

FAIRBANKS METROPOLITAN AREA TRANSPORTATION SYSTEM
INTER-GOVERNMENTAL OPERATING AGREEMENT
AND
MEMORANDUM OF UNDERSTANDING
FOR
TRANSPORTATION AND AIR QUALITY PLANNING

SECTION 1 – PARTIES TO THIS AGREEMENT

The parties to this Agreement are the State of Alaska, the Fairbanks North Star Borough (FNSB), the City of Fairbanks, and the City of North Pole. The Borough is the designated host agency for the Metropolitan Planning Organization (MPO).

SECTION 2 – PURPOSE

This agreement is entered into in accord with 23 U.S. Code § 134 and 49 USC § 5303 – 5306 to provide the structure and process for the continuing, cooperative and comprehensive consideration, development and implementation of transportation and air quality plans and programs for intermodal transportation in the Metropolitan Planning Area (MPA) of the FNSB, 23 USC §134 states in pertinent part:

> It is in the national interest to encourage and promote the safe and efficient management, operation, and development of surface transportation systems that will serve the mobility needs of people and freight and foster economic growth and development within and through urbanized areas and minimize transportation-related fuel consumption and air pollution. To accomplish this objective, the metropolitan planning organization in coordination with the State shall develop transportation plans and programs for urbanized areas of the State. Such plans and programs shall provide for the development of transportation facilities (including pedestrian walkways and bicycle transportation facilities) which will function as an intermodal transportation system for the State, the metropolitan areas, and the Nation. The process for developing such plans and programs shall provide for consideration of all modes of transportation and shall be continuing, cooperative, and comprehensive to the degree appropriate, based on the complexity of the transportation problems. 23 USC §134(a).

SECTION 3 – LEGAL AUTHORITY

3.1 Federal Transportation Planning Statutes

23 USC § 104(f), 23 USC § 134 and 49 USC § 5303 – 5306 provide funding and require designation of a metropolitan planning organization for urbanized areas of at least 50,000 population to carry out a transportation planning process and receive federal funding. Those Statutes require the State and the local governments to coordinate the planning and construction of all urban transportation facilities with a continuing, cooperative, and comprehensive transportation planning process.

3.2 Metropolitan Planning Organization Designation

On April 14, 2003, the Governor of the State of Alaska designated the Metropolitan Planning Organization and identified the Fairbanks Metropolitan Area Transportation System (FMATS) Policy Committee as the policy body providing the direction of transportation planning in the MPO in accordance with Federal law.

3.3 Federal Air Quality Regulations

Air Quality Title 42 USC § 7504 et. seq. requires each area-wide air quality planning agency to prepare an area-wide air quality plan providing for attainment of National Ambient Air Quality Standards (NAAQS). Alaska Statutes Chapter 46.14 requires the Alaska Department of Environmental Conservation (ADEC) to develop a State Implementation Plan (SIP) providing for the attainment of the NAAQS. The FNSB has been designated as the air quality planning agency and has adopted an Air Quality Plan, which is the local component of the SIP. The FNSB is the planning agency that coordinated transportation related air quality planning within the MPO. The Unified Planning Work Program includes the annual preparation of a Reasonable Further Progress Report on Air Quality and review of the goals of the Air Quality Plan. The FMATS Policy Committee must approve the area-wide Air Quality Plan.

SECTION 4 – DEFINED TERMS

As used in this Agreement, the following words and phrases shall have the meanings ascribed unless the context clearly indicates otherwise:

"ADEC" is the State of Alaska Department of Environmental Conservation.

"ADOT&PF" is the State of Alaska Department of Transportation and Public Facilities.

"AIR QUALITY PLAN" is the Fairbanks component of the State Implementation Plan for Air Quality regarding air quality strategies in non-attainment areas.

"ASSEMBLY" is the Fairbanks North Star Borough Assembly, the legislative governing body of the Fairbanks North Star Borough.

"CITY OF FAIRBANKS" is a home rule city, a political subdivision of the State of Alaska.

"CITY OF NORTH POLE" is a home rule city, a political subdivision of the State of Alaska.

"CO" is Carbon Monoxide - a colorless, odorless gas produced due to incomplete combustion of fossil fuels. Alaska has a potential for wintertime health problems with Carbon Monoxide in the Anchorage and Fairbanks areas.

"Conformity" is a process that governs federal actions in non-attainment and maintenance areas to ensure federal projects and programs conform to the State Implementation Plan for Air Quality and do not cause or contribute to new violations of air quality standards.

"Consultation" means that one party confers with another in accordance with an established process and, prior to taking action(s), considers that parties views and periodically informs that party about action(s) taken.

"Cooperation" means that the parties involved in carrying out the planning, programming, and management systems processes work together to achieve a common goal or objective.

"Coordination" means the comparison of the transportation plans, programs, and schedules of one agency with related plans, programs, and schedules of another agencies or entities with legal standing, and adjustment of plans, programs, and schedules to achieve general consistency.

"DOT" or "USDOT" is the United States Department of Transportation.

"DBE" is Disadvantaged Business Enterprise.

"EPA" is the United States Environmental Protection Agency.

"FAIRBANKS CITY COUNCIL" is the legislative governing body of the City of Fairbanks.

"FAIRBANKS NORTH STAR BOROUGH TRANSPORTATION PLAN" establishes the location, classification and minimum right-of-way for those streets and highways required to accommodate the highway transportation needs of the community.

"FHWA" is the Federal Highway Administration, an operating agency of the United States Department of Transportation.

"FMATS" is the Fairbanks Metropolitan Area Transportation System.

"FNSB" is the Fairbanks North Star Borough, a 2nd class borough, a political subdivision of the State of Alaska that includes the City of Fairbanks, the City of North Pole and the Metropolitan Planning Area (MPA) within its boundary.

"FTA" is the Federal Transit Administration, an operating agency of the United States Department of Transportation.

"LRTP" means and shall be referred to as the FMATS adopted Long-Range Transportation Plan and all revisions thereto adopted as the MPO's Metropolitan (official intermodal) Transportation Plan for the Metropolitan Planning Area reviewed and approved in accordance with this Agreement.

"MAJOR AMENDMENTS" are significant changes in the Transportation Improvement Program or Long-Range Transportation Plan. One or more of the following will constitute a major amendment: (1) the addition of a new project requiring an environmental assessment or an environmental impact statement; (2) a change to an existing project that requires an air quality conformity determination; (3) a change in a project that requires a change in a previously approved environmental assessment or environmental impact statement; (4) the deletion of a project. (17 AAC 05.195)

"MINOR AMENDMENTS" are non-significant new projects or a change in an existing project in the Transportation Improvement Program or Long-Range Transportation Plan.

"MPA" or "METROPOLITAN PLANNING AREA" means the geographic area determined pursuant to 23 USC § 134(c) in which the MPO carries out the development and implementation of transportation and air quality plans and programs under 23 USC § 134 and the Federal Transit Act § 8, respectively (shown in Attachment #1 to this Agreement).

"MPO" or "METROPOLITAN PLANNING ORGANIZATION" is the cooperative transportation planning organization for the Metropolitan Planning Area.

"NAAQS" is the National Ambient Air Quality Standards.

"NON-ATTAINMENT AREA" is that portion of the Metropolitan Planning Area, which has been designated as an air quality non-attainment area in the Federal Register (shown in Attachment #1 to this Agreement).

"NORTH POLE CITY COUNCIL" is the legislative governing body of the City of North Pole.

"PL" is the Metropolitan Transportation Planning funds authorized by 23 USC § 134.

"PLANNING COMMISSION" is the Fairbanks North Star Borough Planning Commission.

"POLICY COMMITTEE" OR "FMATS POLICY COMMITTEE" is the FMATS Policy Committee established in Section 5.2 of this Agreement for the cooperative decision making in accordance with this Agreement.

"SECTION 5303" – A Federal Transit Administration grant program fund designed to establish a cooperative, continuous, and comprehensive framework for making transportation investment decisions in metropolitan areas.

"SIP" or "STATE IMPLEMENTATION PLAN" is the State of Alaska Air Quality Implementation Plan.

"STATE" is the State of Alaska.

"STIP" is the Statewide Transportation Improvement Program, which is the State's three year, statewide, financially constrained intermodal program of transportation projects. The STIP is consistent with the statewide transportation plan, and incorporates the TIP. It is developed pursuant to 23 USC § 135(f) and is approved by the Commissioner of ADOT&PF, the Governor, FTA and FHWA.

"TECHNICAL COMMITTEE" or "FMATS TECHNICAL COMMITTEE" is the FMATS Technical Committee established in Section 5.3 of this Agreement for the cooperative decision making in accordance with this Agreement.

"TIP" is the Transportation Improvement Program, which is the FMATS' three year, financially constrained, intermodal program of transportation projects consistent with the FMATS LRTP for funding Metropolitan Planning Area transportation improvements, updated at least every two years and approved by the FMATS Policy Committee and the Governor in accordance with this Agreement.

"UPWP" is the Unified Planning Work Program, which is the two year operating program detailing funding and responsibilities for transportation planning and air quality work tasks within the Metropolitan Planning Area. The UPWP provides for a continuing and comprehensive transportation planning process carried out by FMATS.

SECTION 5 – ORGANIZATION AND RESPONSIBILITIES

5.1 FMATS

FMATS is the balanced, cooperative, coordinated and comprehensive process between the MPO and State for the development of an FMATS Long-Range Transportation Plan, Transportation Improvement Program, Unified Planning Work Program and the Air Quality Plan.

5.1.1 In order to receive and expend federal funding for transportation and air quality improvements there must be coordination between the State and the MPO as required by federal regulation. Therefore, the purpose of FMATS is to provide the framework and mechanism for the MPO and the State to jointly develop and implement transportation and air quality plans and programs, which will assure compliance with State and Federal transportation planning and air quality requirements. The duties and responsibilities within FMATS are further described in this section.

5.1.2 FMATS is responsible for the metropolitan transportation planning process within the urbanized boundaries in accordance with the Unified Planning Work Program approved by the Policy Committee, the State, the FHWA, and the FTA.

5.2 FMATS Policy Committee

The Fairbanks Metropolitan Area Policy Committee, hereafter referred to as the "Policy Committee", shall have as members, the Northern Region Director of the State of Alaska Department of Transportation and Public Facilities (ADOT&PF), the Fairbanks North Star Borough (FNSB) Mayor, the Mayor of the City of Fairbanks, the Mayor of the City of North Pole, a representative of the State of Alaska Department of Environmental Conservation (Air Quality), a designated representative of the FNSB Assembly, and a designated representative of the Fairbanks City Council. Each member of the Policy Committee shall have one vote.

5.2.1 The Powers and Duties of the FMATS Policy Committee

The FMATS Policy Committee shall have overall responsibility for the implementation of this Agreement, coordination of the FMATS' efforts and responsibilities of the Technical Committee, and the ultimate development and adoption of the FMATS UPWP, FMATS TIP, FMATS LRTP and Air Quality Plan.

5.3 FMATS Technical Committee

There shall be a Technical Committee. Each member of the Technical Committee shall have one vote and all actions of the Technical Committee, including recommendations to the Policy Committee, shall be by a majority vote of the total authorized number of members.

5.4 Metropolitan Planning Area (MPA) under 23 USC § 134(c)

The Metropolitan Planning Area specified by 23 USC § 134(c) shall be the geographical area shown on Attachment #1 to the Agreement incorporated hereto by reference. Provided such boundaries conform to the requirements of 23 USC § 134(c), the MPO and the Governor may mutually agree to change the boundaries of the Metropolitan Planning Area.

SECTION 6 – KEY PLANS and PROGRAMS

6.1 There are four primary planning or programming activities that FMATS is responsible for developing. This section summarizes these key plans and programs, which include the Air Quality Plan, FMATS Long-Range Transportation Plan, Transportation Improvement Program, and FMATS Unified Planning Work Program.

6.1.1 Air Quality Plan

The Fairbanks North Star Borough, with full assistance from DEC, the MPO and all other cooperating agencies, is responsible for developing and updating an Air Quality Plan, which shall:

(1) Identify area-wide objectives and policies required to attain and maintain the NAAQS for carbon monoxide (CO) for the Metropolitan Planning Area;

(2) Inventory technical, physical, and other air quality planning data;

(3) Analyze alternatives and establish strategies designed to attain and maintain the NAAQS for the Metropolitan Planning Area;

(4) Address any other air quality issues required by the EPA or US Department of Transportation;

(5) Provide for the implementation of the adopted air quality strategies as expeditiously as practical; and

(6) Provide for and show reasonable further progress towards achievement of carbon monoxide standards within the non-attainment area.

6.1.2 FMATS Long-Range Transportation Plan

The MPO, in cooperation with the State, is responsible for developing or updating a FMATS Long-Range Transportation Plan. The MPO shall follow the latest federal planning requirements, as prescribed in 23 CFR 450.322.

6.1.3 Transportation Improvement Program

The MPO, in cooperation with the State, is responsible for developing or updating the FMATS Transportation Improvement Program. The MPO shall follow the latest federal planning requirements, as prescribed in 23 CFR 450.324.

6.1.4 Unified Planning Work Program

(1) The MPO, with full assistance from the State and all other cooperating agencies, is responsible for developing or adjusting the FMATS Unified Planning Work Program. The MPO shall:

(a) Describe all the transportation and air quality planning and operational activities to be completed in a calendar year.

(b) Ensure early coordination with FHWA and FTA.

(2) No later than July 1 of each year, ADOT&PF shall submit to the FMATS Policy Committee in writing the amount of estimated Federal PL and Section 5303 funds, and required match ratios, to be made available to FMATS for the next fiscal year of October 1 through September 30. ADOT&PF shall recommend work tasks with budgets for tasks in which it participates. FMATS staff shall develop and implement a UPWP public involvement program and prepare a UPWP with the full cooperation of ADOT&PF and the FMATS Technical Committee. Discussions between ADOT&PF and FMATS shall take place to determine how the proposed tasks can be accomplished in the most efficient and effective manner. The FMATS UPWP shall be reviewed by the FMATS Technical Committee, approved by the FMATS Policy Committee, and forwarded to ADOT&PF for concurrent approval by FHWA and FTA prior to any work being performed.

6.2 Changes/Amendments to Key Plans and Programs

6.2.1 A Major Amendment or Revision

The FMATS Policy Committee, with its responsibility to maintain existing plans and programs, shall approve major amendments. Major amendments will include a public involvement period consistent with FMATS public involvement policy. When written and oral comments are received on the draft FMATS LRTP or the FMATS TIP, a summary, analysis, or report on the nature of the comments shall be made part of the final FMATS LRTP and/or FMATS TIP as part of the document or as an appendix.

6.2.2 A Minor Amendment or Revision:

The FMATS Technical Committee, with its responsibility to maintain existing plans and programs while meeting the overall policy direction set by the FMATS Policy Committee, shall approve minor amendments. Minor amendments to the FMATS LRTP or FMATS TIP do not require FMATS Policy Committee approval, and no public review will be required. Notification of such amendments will be provided as information to the FMATS Policy Committee following the Technical Committee action.

6.2.3 Amendments/Changes to the FMATS Unified Planning Work Program (UPWP).

Changes in work assignments and studies to be performed to meet the air quality and transportation planning requirements may be made by the FMATS Policy Committee at such times and to such extent as deemed necessary. Total funds to be made available for the performance of said work and services shall not exceed the amount specified in the FMATS UPWP. Reimbursement will be made by ADOT&PF in accordance with procedures stated herein, and shall be expended only on the FMATS UPWP approved by the FMATS Policy Committee, the State, FHWA and FTA.

(1) Changes in funding levels for tasks, or changes in tasks, shall be requested as soon as possible after the need for such change is recognized.

(a) Major FMATS UPWP Adjustments
(No additional funding required)
Cumulative adjustments to the task budget amounts that exceed 10 percent of the original approved program budget, individual changes of $25,000 or more to task budgets, or significant scope changes require the concurrence of the

FMATS Policy Committee, ADOT&PF, FHWA and FTA before becoming effective.

(b) Minor FMATS UPWP Adjustments
(No additional funding required and no changes to scope)
The ADOT&PF Fairbanks Area Transportation Planner in conjunction with the FNSB Transportation Planner shall approve changes to the task budgets that do not exceed 10 percent of the approved program budget or individual changes of $25,000 of a task budget require. A minor adjustment requires the concurrence of the FMATS Policy Committee Chair and ADOT&PF before becoming effective. The Policy Committee, FHWA and FTA will be notified as soon as possible of these changes.

(c) Program Total Funding Adjustments
Requests for additional program funding will require the approval of FMATS Policy Committee, ADOT&PF, FHWA, and FTA.

SECTION 7 – CONSULTANT CONTRACTS

7.1 FHWA and FTA Approval: For all federally funded work to be done under a consultant contract, prior FHWA approval is required before a Request For Proposal (RFP) is issued. Early coordination is essential. The contracting agency will provide ADOT&PF with a draft Scope of Services for review and submittal to ADOT&PF Headquarters, FHWA and FTA.

7.2 ADOT&PF Approval: The contracting agency will coordinate with ADOT&PF to review the final RFP, Scope of Services, project budget and project management plan. ADOT&PF shall also have an opportunity to serve on the Selection Committee.

7.3 Work Products: ADOT&PF will have an opportunity to review draft work products prior to review by the Technical and Policy Committees.

SECTION 8 – INSPECTION OF WORK

ADOT&PF, as well as FHWA and FTA, shall at all times be accorded review and inspection of the work and shall at all reasonable times have access to the premises, to all data, notes, records, correspondence, and instruction memoranda or description which pertain to the work involved in the FMATS UPWP.

SECTION 9 – ADDITIONAL AND SEPARATE WORK PROJECTS

From time to time, ADOT&PF or the MPO may desire one of the other parties to perform additional work projects for services separate and apart from those set forth in the FMATS UPWP. At such times, the requesting party will notify the other party of the intention, including a request for the specific work and/or services desired. If there is a willingness and ability to do the work or perform the services requested, written acceptance by the requesting party of the terms accepted shall constitute authority to proceed with the work and/or services requested. The requesting party shall pay for such work or services within a reasonable time after billing. Such billing shall be made pursuant to the terms agreed upon for each particular work project.

SECTION 10 – PROGRAM REPORTING REQUIREMENTS

10.1 Reporting: UPWP

The MPO, with the full support of the other parties involved, shall report regularly upon the status of such planning and progress made on associated documents. Copies of the report will be provided to the Policy and Technical Committees for their information. The reporting procedures shall include, but not limited to, the following:

10.1.1 Quarterly Reports:

A quarterly financial statement, narrative progress report, and transit element report shall be submitted to ADOT&PF no later than the 23rd day following the last day of each FMATS UPWP fiscal quarter, in order to meet the requirements of 49 CFR 18.40 as supplemented by 23 CFR 420.113.

Within 30 days of the last day of the fiscal quarter, ADOT&PF shall either, review and approve the report, or request modifications. ADOT&PF Northern Region staff will forward the report to ADOT&PF Headquarters. It will be reviewed and forwarded to FTA and FHWA to meet the reporting requirements of 23 CFR 420.

If ADOT&PF staff request modifications, the report will be forwarded to ADOT&PF Headquarters staff as a draft report. The MPO shall then convey a revised submittal to ADOT&PF no later than 40 days following the last day of each fiscal year quarter. ADOT&PF shall approve or request additional modifications to the re-submittal no later than 50 days following the last day of each fiscal year quarter.

This final quarterly report shall serve as the basis for reimbursement and shall consist of the following:

(1) Financial statement shall include task and program summary of the following data:

(a) Current quarterly expenditures
(b) Fiscal year to date expenditures
(c) PL, Sec. 5303, and local funds/in-kind expended to date
(d) PL, Sec. 5303, and local funds/in-kind remaining

(2) Narrative progress report shall include:

(a) A description of work accomplished during the quarter
(b) Significant events (i.e. travel, training, conferences)
(c) Milestones reached in sufficient detail to justify the quarterly expenditures

For each task, the percentage complete shall be given, how the scheduled completion date matches the program estimated date, as well as the estimated completion date. Explanatory information shall be provided if the estimated completion date differs from the date contained in the UPWP.

(3) The transit element report shall be in the format prescribed by the ADOT&PF Statewide Transit Coordinator and FTA.

10.1.2 Annual Report

The annual report for the FMATS UPWP fiscal year will contain an annual technical report concerning and summarizing the pertinent development, activities, and accomplishments of the tasks outlined within the UPWP of the past fiscal year. The annual technical report will be submitted within 60 days of the end of the fiscal year.

The report will contain:
(1) A complete comparison of actual performance with established goal
(2) Status of expenditures comparing budgeted (approved) amounts with actual costs incurred
(3) Identify overruns and underruns and all information being consistent with FMATS UPWP revisions

10.1.3 Significant Events

Events that have significant impact on the work program shall be reported as soon as they become known. The type of events or conditions that require reporting include problems, delays or adverse conditions that materially affect the ability to attain program objectives. This disclosure shall be accompanied by a statement of the action taken or contemplated, and any state or federal assistance required resolving the situation.

10.1.4 Other Reports

Copies of formal reports, informal reports, and material emerging out of a task specified in the UPWP shall be governed by Section 11 of this Agreement.

SECTION 11 – PLANNING REPORTS

11.1 Planning Reports:

From time to time, ADOT&PF and the MPO may publish reports, documents, etc., upon completion of a portion and/or a phase of a particular planning element in the continuing transportation planning process. In order for the preparation and publishing of such reports to be eligible for participation of Federal funds, the FMATS Technical Committee shall review the report.

11.2 Publication

Publication by any party to the Agreement shall give credit to other parties, FTA and FHWA. However, if any party, FTA or FHWA does not wish to subscribe to the findings or conclusion of the study, the following statement shall be added:

"The opinions, findings, and conclusions expressed in the publication are those of the authors and not necessarily those of the [excluded party(ies)] or the FTA and FHWA".

Furthermore, consultant logo's are prohibited from the cover of all reports, documents, etc. that are approved by FTA and FHWA.

11.3 Copies

One (1) Draft report will be submitted for review and two (2) final reports will be submitted for approval to the following agencies:

- Fairbanks North Star Borough
- ADOT&PF Northern Region Planning

- ADOT&PF Statewide Planning
- Federal Highway Administration
- Federal Transit Administration

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SECTION 12 – DIVISION OF COST AND PAYMENT

12.1 Reimbursement

The maximum amount of Metropolitan Planning Funds available each year for reimbursement to the FNSB shall not exceed the budget approved in the FMATS UPWP or as amended. ADOT&PF will make reimbursement in accordance with the following procedures:

(1) The FNSB shall submit to ADOT&PF a quarterly narrative progress report and financial statement, as defined in Section 10 of this Agreement.

(2) Reimbursement will be made within 30 days after ADOT&PF receipt and approval of the quarterly narrative progress reports and financial statements, subject to Federal planning funds being made available and received for the allowable cost.

(3) Within 60 days of ADOT&PF approval of the last quarter narrative progress report and financial statement for the fiscal year, ADOT&PF will close the FMATS UPWP account and request that an audit be performed.

(4) The audit will be completed and final payment adjustments made within 120 days of the last quarter or to the extent possible.

12.2 ADOT&PF Tasks:

The parties may agree that ADOT&PF can most efficiently and effectively perform a task or a portion of a task to be funded with PL funds in the approved UPWP. In such cases, ADOT&PF shall:

(1) Provide the MPO with all necessary documentation in order to permit the preparation of the reports required in Section 10 of this Agreement, Program Reporting Requirements.

(2) Upon ADOT&PF approval of the quarterly narrative progress reports and financial statements, ADOT&PF shall submit a billing to FHWA for direct payment to ADOT&PF for approved FNSB UPWP costs.

(3) ADOT&PF shall be reimbursed at the rate contained in the applicable Unified Planning Work Program.

(4) ADOT&PF shall promptly provide the MPO with copies of its billings and statements.

12.3 Overruns:

The ADOT&PF and the FNSB acknowledge that they will receive benefits from the information developed by performance of the elements outlined in the FMATS UPWP. They agree to pay that portion of their element costs which exceed the total program funding level budgeted for the agency, as shown in the FMATS UPWP, without recourse to the other parties.

12. 4 Cost Limitations:

Reimbursement of administrative and operational costs will be made without profit or markup. These costs shall be limited to:

(1) Direct salaries and wages, with payroll taxes and fringe benefits at actual costs, or if prorated to be allocated on an equitable basis;

(2) Telephone charges and necessary travel limited to program specific charges;

(3) Overhead or indirect costs as approved annually in the respective FMATS UPWP line item budget and verified by audit. Such overhead shall be allocated on an equitable basis. Eligibility shall conform to the provisions of 23 CFR 420.111(c);

(4) Training as approved specifically in the FMATS UPWP or otherwise specifically approved by ADOT&PF, FHWA or FTA.

12.5 Rate of Reimbursement:

Reimbursement shall be at the rate specified and contained in the applicable FMATS UPWP.

12.6 Financial Accounting Level:

The expended funds will be accounted for at the task level (110, 120, 130, etc.).

12.7 Fiscal Year:

The FMATS UPWP fiscal year will be October 1 to September 30.

SECTION 13 – PROCUREMENT, MANAGEMENT, AND DISPOSITION OF PROPERTY

Procurement and management of property acquired for the program, including disposition of property if the program is discontinued, will be in accordance with 48 CFR, and 49 CFR 18.31 – 33.

SECTION 14 – AUDIT PROCEDURES

14.1 In addition to the requirements stated in this section, requirements for audit as defined in 23 CFR 420 and 49 CFR 18 will be used as guidelines. Also, with respect to contract cost principles and procedures, 48 CFR 31 will be used as guidelines.

14.2 Each participating party will maintain complete records of all manpower, materials and out-of-pocket expenses, and will accomplish all record keeping in accordance with the following procedures:

14.2.1 Each participating party will furnish ADOT&PF copies of all certified payrolls which shall include the hourly rate for each employee working on the project during the reporting period. In addition, a loaded rate factor will be shown in a manner compatible with existing FNSB procedures. The load rate factor is subject to adjustment based upon audits occurring during the life of this Agreement.

14.2.2 Time Sheets

Individual time sheets will be maintained reflecting the daily total amount of hours worked and amount of time spent on each task within the program. It is imperative that the hours be traceable to the task.

14.2.3 Materials

Copies of invoices shall support costs of any purchased materials utilized on this project.

14.2.4 Out-of-Pocket Expenses

Copies of receipts shall support all expenses.

14.2.5 Record System

The record system will be such that all costs can be easily traceable from all billings through the ledgers to the source document. Each expenditure must be identified with the task within the current approved FMATS UPWP.

14.2.6 Cost Overruns

When expenditures are anticipated to overrun in one FMATS UPWP work element, the procedures for budget changes as outlined in Section 6.2 must be followed.

14.3 Each consultant contract or professional services agreement, in which the FNSB or the ADOT&PF engages, may require a specific audit for that project or agreement. The award of any such construction related engineering design services contract must be made in conformity with applicable Federal and ADOT&PF contracting procedures including ADOT&PF Procedure 10.02.010, and related Professional Services Agreement Handbook, or based on acceptable alternative contracting procedures approved by ADOT&PF and FHWA. This requirement is in addition to any agency-wide audit conducted pursuant to 23 CFR 12 – Single Audit Requirements.

14.4 The FMATS Program is to be audited every two years by ADOT&PF Internal Review auditors to insure adequate coverage. ADOT&PF and the FNSB and/or its subcontractors under this Agreement shall maintain all records and accounts relating to its costs and expenditures for the work during any fiscal year for a minimum of three (3) years following receipt of the final payment, and shall make them available for audit by representatives of ADOT&PF, FHWA and FTA at reasonable times. The FNSB shall maintain records in a form approved by ADOT&PF. Final payment is defined as the final voucher paid by FHWA to ADOT&PF based on an audit. A FNSB request to close out a fiscal year or project account does not constitute final payment.

14.5 Any review, which does not meet Federal requirements, will be resolved between ADOT&PF and the FNSB. The financial records relating to a FMATS UPWP year may be closed out once FHWA accepts the audit and final payment adjustments have been made.

SECTION 15 – COMPLIANCE WITH TITLE VI, CIVIL RIGHTS ACT OF 1964

15.1 The FNSB hereby agrees as a condition to receiving any Federal financial assistance from the USDOT, to comply with Title VI of the Civil Rights Act of

1964, (78 Statute 252, 42 USC § 2000d – 2000d-4 hereinafter referred to as the "Act") and all requirements imposed by or pursuant to Title 49 CFR, USDOT, Subtitle A, Office of the Secretary, Part 21, Nondiscrimination in Federally-assisted Programs of the USDOT, Effectuation of Title VI of the Civil Rights Act of 1964 (hereinafter referred to as the "Regulations"), 49 CFR 26 Participation of Disadvantage Business Enterprises in Department of Transportation financial assistance programs, and the Americans with Disabilities Act and other pertinent directives to the end that in accordance with the Act, Regulations, and other pertinent directives, no person in the United States shall on the grounds of race, color, sex, or national origin be excluded from participation in, be denied the benefits of , or activity for which the FNSB receives Federal financial assistance from the USDOT, including FHWA and FTA, and hereby gives assurance that is will promptly take any measure necessary to effectuate this Agreement. This Assurance is required by 49 CFR 21.7A(1).

15.2 More specifically, and without limiting the above general assurance, the FNSB hereby gives the following specific assurance with respect to the project:

15.2.1 The FNSB agrees that each "program" and "facility" as defined in subsections 21.23(b) and (e) of the Regulations, will be (with regard to a program) conducted or will be (with regard to a facility) operated in compliance with all requirements imposed by, or pursuant to, the Regulations

15.2.2 The FNSB shall insert the clauses of this assurance in every contract subject to the Act and Regulations.

15.2.3 Where the FNSB received Federal financial assistance to carry out a program of managerial training, under 49 USC § 5303 – 5306, the assurance shall obligate the FNSB to make selection of the trainee without regard to race, color, sex, or national origin.

15.2.4 Where the FNSB receives Federal financial assistance to carry out a program under 49 USC § 5303 – 5306, the assurance shall obligate the FNSB to assign transit operators, and to furnish transit operators, for charter purposes without regard to race, color, sex, or national origin.

15.2.5 Where the FNSB receives Federal financial assistance to carry out a program under the 49 USC § 5303 – 5306, routing scheduling, quality of service, frequency of service, age/quality of vehicles assigned to routes, quality of stations serving different routes, and locations of routes may not be determined on the basis of race, color, sex, or national origin.

15.2.6 This assurance obligates the FNSB for the period during which Federal financial assistance is extended to the projects, except where the Federal financial assistance is to provide, or is in the form of, personal property, or real property or interest therein or structures or improvements thereon; in which case the assurance obligates FNSB or any transferee for the longer of the following periods: a) The period during which the property is used for a purpose for which the Federal financial assistance is extended, or for another purpose involving the provision of similar services or benefits; or b) the period during which the FNSB retains ownership or possession of the property.

15.2.7 The FNSB shall provide for such methods of administration for the program, as are found by the Secretary of Transportation or the official to whom he delegates specific authority to give reasonable guarantee that it, other FNSB sub-grantees, contractors, subcontractors, transferees, successors in interest, and other participants of Federal financial assistance under such program will comply with all requirements imposed or pursuant to the Act, the Regulations, and this Assurance.

15.2.8 The FNSB agrees that the United States has a right to seek judicial enforcement with regard to any matter arising under the Act, Regulations and this Assurance.

15.3 This Assurance is given in consideration of and for the purpose of obtaining, any and all Federal grants, loans, contracts, property, discounts, or other Federal financial assistance extended after the date thereof to the FNSB by the FHWA and/or FTA programs and is binding on it, other FNSB sub-grantees, contractors, subcontractors, transferees, successors in interest, and other participants in FHWA and/or FTA programs. The person or persons whose signature appears below are authorized to sign this assurance on behalf of the FNSB.

SECTION 16 – DISADVANTAGED BUSINESS ENTERPRISES (DBE) PROGRAM REQUIREMENTS

16.1 Compliance

The parties, their agents and employees shall comply with the provisions of 49 CFR 26 and Title VI of the Civil Rights Act of 1964. 49 CFR 26 requires that all parties shall agree to abide by the statements in paragraphs 16.2 and 16.3 and shall include these statements in the FNSB USDOT financial assistance agreement and in all subsequent agreements between the FNSB and any sub-grantees and any contractor.

16.2 Policy

It is the policy of the USDOT that Disadvantaged Business Enterprises (DBE), as defined in 49 CFR 26 shall have an equal opportunity to participate in the performance of contracts finances in whole or part with Federal funds under this Agreement. Consequently the DBE requirements of 49 CFR 26 apply to this Agreement.

16.3 DBE Obligation

The Parties to this Agreement or their contractors agrees to ensure that Disadvantaged Business Enterprises (DBE), as defined in 49 CFR 26 have an equal opportunity to participate in the performance of contracts and sub-contracts financed in whole or part with Federal funds provided under this Agreement. In this regard the Parties to this Agreement and/or their contractors shall not discriminate on the basis of race, color, national origin, or sex in the award and performance of USDOT assisted contracts.

SECTION 17 - AMENDMENTS

This Agreement may be amended only in writing, and must be done prior to undertaking changes or work resulting therefrom or incurring additional costs or any extension of time. Said amendments are subject to approval by the FMATS Policy Committee and the State of Alaska.

SECTION 18 – LIMITATION OF LIABILITY

No liability shall be attached to the State and/or the FNSB by reason of entering into this Agreement, except as expressly provided herein.

SECTION 19 – COMPLIANCE WITH LAWS

In addition to the laws, statutes, regulations and requirements stated herein, all Parties to this Agreement shall be knowledgeable of and comply with all Federal, State and local laws and ordinances applicable to the work to be done under this Agreement.

SECTION 20 – TERMINATION OF AGREEMENT

This Agreement will continue in force until or unless the Parties terminate the Agreement in writing.

SIGNATURES

Mayor – Fairbanks North Star Borough

3/28/02
Date

Mayor – City of Fairbanks

3/11/03
Date

Mayor – City of North Pole

3/11/03
Date

Governor – State of Alaska

4-15-03
Date


Fairbanks Metropolitan Area
Transportation System
Planning Area
STEESE HWY
GOLDSTREAM RD
NEW STEESE EXPY
BALLAINE RD
FARMERS LOOP RD
SHEEP CREEK RD
CHENA HOT SPRINGS RD
NORDALE RD
JOHANSEN EXPY
GEIST RD
OLD NENANA HWY
CHENA RIDGE RD
CHENA PUMP RD
MITCHELL EXPY
City of Fairbanks
BADGER RD
GEORGE S PARKS HWY
RICHARDSON HWY
City of North Pole
Legend
Municipal Boundaries
MPO/Urban Area Boundary
City of Fairbanks
City of North Pole
Urban Census Boundary
Carbon Monoxide Maintenance Area
PM 2.5 Boundary
Road Classification
Arterial
Major Collector
Minor Collector
Local Road
Railroad
0 0.25 0.5 1 1.5 2
Miles
N

Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.3

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan }

Adopted

September 7, 2016

Bill Walker
Governor

Larry Hartig
Commissioner

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Appendix III.D.5.3

Non-Attainment Area Boundary

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Fairbanks

The nonattainment boundary proposed by EPA for Fairbanks encompasses an area that is substantially larger than the nonattainment area recommended by the state. Presented below is a summary of local data that adds to and correct EPA's Technical Analysis for the Fairbanks, Alaska Nonattainment Area. This information serves to support a modified nonattainment area boundary that differs from both ADEC's original recommendation and EPA's proposal. A revised nonattainment boundary is included for consideration. We believe this boundary is appropriate, defensible, and based on the best local data currently available. The new data include updated emissions, monitoring data from the past winter, particulate matter monitoring data from the local military bases, additional meteorological analyses, and updated population and growth information.

Should EPA determine that these additional data do not support the modified boundary, ADEC encourages the consideration of options that allow for additional data to be included. ADEC and the Fairbanks North Star Borough have initiated an extensive monitoring program for this coming winter that will provide insight into source-specific contributions as well as the size and extent of the area exceeding the 24-hour $PM_{2.5}$ standard. This $2.64 million dollar effort is underway and will generate significant new data over the next winter that would inform a final boundary based on meaningful and real data, not supposition. In addition, EPA is engaged in a $PM_{2.5}$ modeling research program in the Fairbanks area that will also inform the decision process. ADEC requests that EPA consider these data in defining a technically supported boundary that can be justified to the public.

ADEC believes there are two options available to allow for the time needed to make an informed boundary decision. First, EPA could use the extension provided under the CAA Section 107(d)(1)(B)(i), where the designation period can be extended for up to one year if the Administrator needs additional information. This would allow data from this winter's effort to be submitted and considered in the boundary decision. Resolutions supporting this position have been made by the Fairbanks North Star Borough[1], the Fairbanks Metropolitan Area Transportation System[2], the City of Fairbanks[3], the Pollution Control Commission[4](to minimize the size of this document, these references will be submitted in a separate zip file, entitled Fairbanks Resolutions). A letter from the

[1] Fairbanks North Star Borough, Resolution 2008 – 37, A Resolution a One-Year's Extension to EPA's Final Designation Decision of the $PM_{2.5}$ Nonattainment Boundaries in the Fairbanks Banks North Star Borough, adopted 10/09/08

[2] Letter from Steve Titus, FMAT Chair to EPA Docket No. EPA-HR-OAR-2007-0562, Subject "Comments on EPA Responses to State and Tribal 2006 24-Hour $PM_{2.5}$ Designation Recommendation", September 17, 2008

[3] City of Fairbanks Resolution No. 4341, A Resolution Requesting the Environmental Protection Agency Delay Any Designation of the Fairbanks North Star Borough as a $PM_{2.5}$ Nonattainment Area for at Least One Year, approved September 22, 2008

[4] Letter from Chuck Machetta, Chairman PCC to EPA Docket No. EPA-HR-OAR-2007-0562, Subject "Comments on EPA Responses to State and Tribal 2006 24-Hour $PM_{2.5}$ Designation Recommendation", September 19, 2008

Mayor of Fairbanks to EPA also requested an extension.[5] Second, EPA could consider and implement the proposal by ADEC to set a smaller boundary now and then expand the boundary in the future, if warranted, based on the data collected this winter. This would allow for timely initiation of the air quality planning process, but still recognize the uncertainty in the scope of the problem and sources involved.

Factor 1: Pollutant Emissions

The estimated annual emissions for the Fairbanks North Star Borough for calendar year 2005 are shown in Table 1. Emission sources are located primarily in the populated areas of the borough; however, there are two notable source categories that are either naturally occurring or not focused inside the urban areas. These sources are wildfire emissions, which dominate emissions overall in the area source category, and dust from unpaved roads, which dominate the particulate matter emissions in the non-road mobile source category. Neither of these sources, however, is active during the winter months when high concentrations of $PM_{2.5}$ occur.

Table 1
Summary of Fairbanks Emissions in 2005
(tons/year)

Source Category	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
Point	67	5,829	4,565	460	NA	NA	1,087
Area	4,473	1,872	1,055	7,523	6,444	337	76,433
Mobile - Onroad	1,160	2,218	161	71	56	55	14,510
Mobile - Nonroad	1,241	543	34	19,245	3,398	0	6144
Total Emissions	**6,941**	**10,462**	**5,815**	**27,299**	**9,898**	**392**	**98,174**

Tables summarizing the detailed data for each source category are included as Attachment A.

Due to a data error, there has been confusion regarding the location and number of point sources within the Fairbanks North Star Borough and EPA's proposed nonattainment boundary. In order to clarify this, Table 2 provides a summary of the permitted major facilities that are actually located and operating within EPA's proposed nonattainment boundary and their reported actual emissions for calendar year 2005.

[5] Letter from Jim Whitaker, Major of Fairbanks to Robert Myers, Principal Deputy Assistant Administrator, Office of Air and Radiation, Subject "$PM_{2.5}$ Boundary", September 12, 2008

Table 2 Reported Emissions in 2005 from Permitted Major Facilities Within EPA's Proposed Nonattainment Boundary (tons per year)					
Facility	VOC	NOx	SO_2	PM_{10}_PRI	CO
Aurora Energy LLC Chena Power Plant	0	629	248	353	459
Flint Hills Resources Alaska, LLC North Pole Refinery	35	215	13	15	33
Golden Valley Electric Association North Pole Power Plant	2	3,604	3,019	50	14
Golden Valley Electric Association Zehnder Facility	1	28	24	0	1
US Air Force Eielson Air Force Base	21	367	281	8	125
US Army Fort Wainwright	6	471	697	14	262
University of Alaska Fairbanks Campus Power Plant	2	509	280	7	187
Wilder Construction Company Asphalt Plant*	0	6	3	13	6
Total Point Source Emissions	67	5,829	4,565	460	1,087

*Asphalt plant does not operate in winter when violations occur

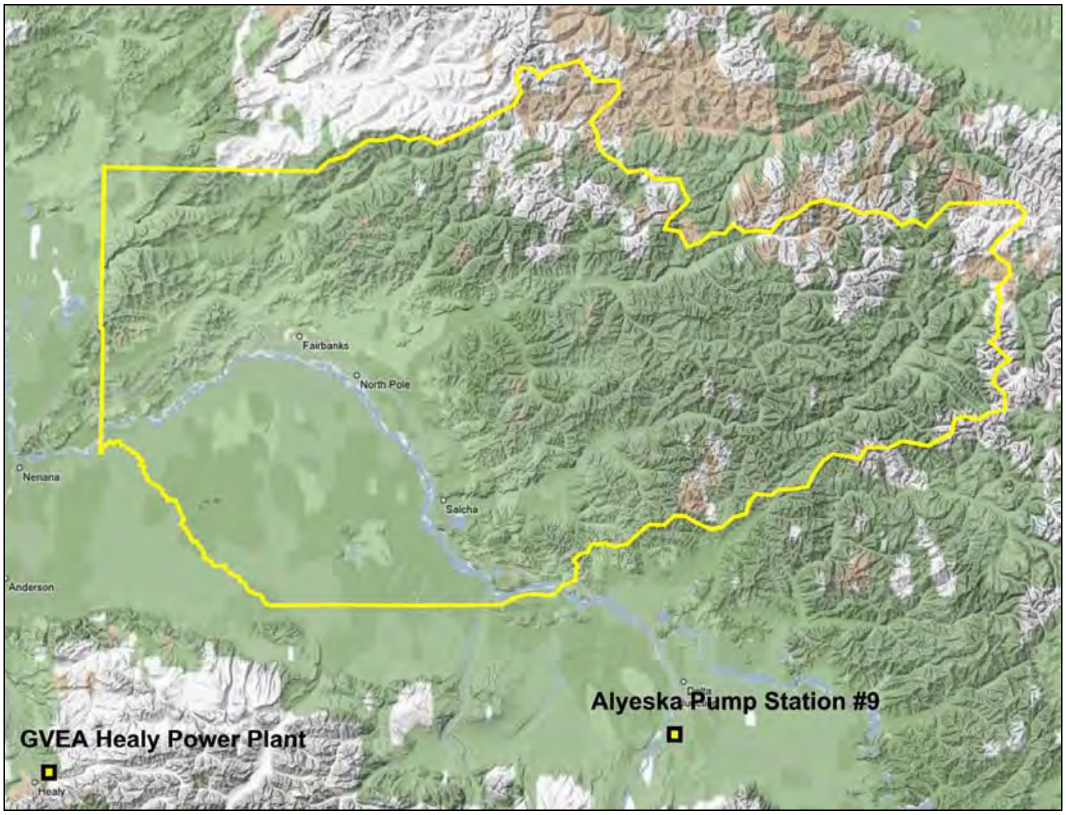
Alyeska TransAlaska Pipeline Pump Station #8 is no longer a major point source inside the Fairbanks North Star Borough. Pump Station #8 was placed in standby June 30, 1996 and its air quality permit was rescinded in April 2008. Figure 1 shows that the following facilities are not located within either the Fairbanks North Star Borough or EPA's proposed nonattainment area:

- Alyeska TransAlaska Pipeline Pump Station #9 – Located near Delta Junction, 105 miles from Fairbanks; and
- GVEA Healy Power Plant – Located in Healy, Alaska, approximately 100 miles south of Fairbanks.

Further information on the TransAlaska Pipeline pump stations may be found on the Alyeska Pipeline Service Company web site at http://www.alyeska-pipe.com/PipelineFacts/PumpStations.html

In a separate submission (to minimize the size of this document, the memorandum will be submitted in a separate zip file entitled "Eielson Memorandum", the attachments to the memorandum will be in a separate zipped file entitled "Eielson Attachments") Eielson Air Force Base provides data demonstrating that the principal source of emissions at the base is the Central Heat and Power Plant (CHPP). The 2007 values presented in that submission are quite similar to those presented in Table 2 and reflect the benefits of the recently installed full-stream bag houses. A comparison between the NOx and SO_2 values emitted by the CHPP and the totals presented in Table 1 show its share of precursor emissions to be below 5% for both pollutants. For the one-year period between June 2007 and May 2008, data submitted for the Blair Lakes Range Facility, a training

Figure 1
Location of Permitted Facilities Outside of Fairbanks North Star Borough Boundary



range located approximately 23 miles south of Fairbanks, showed emissions of 4.6 tons of PM_{10} and 35 tons of SO_2. The range's share of the totals presented in Table 1 is well below 1% for both pollutants. Additional information on winter training activity within both the Blair Lakes and Stewart Creek Ranges found that low level sorties (i.e., those most likely to impact ambient concentrations of $PM_{2.5}$) are flown at a rate of approximately one sortie every four days. Both facilities are located approximately 25 miles from Fairbanks.

A submission from Fort Wainwright (to minimize the size of this document, the memorandum will be submitted in a separate zip file entitled "Wainwright Letter") provides information on winter activity within two training areas located to the south of the Tanana River: the Tanana Flats Training Area (TFTA) and the Yukon Training Area (YTA). While no estimate of emissions is provided, the information demonstrates that winter activity within these facilities is extremely limited.

Summary – Source-specific emission estimates show that area and nonroad sources are responsible for 99% of directly emitted $PM_{2.5}$ and that point sources are responsible for 79% of the SO_2 and 56% of the NOx emitted in Fairbanks. A summary of major permitted facilities showed that two facilities are not located within the Fairbanks North Star Borough or EPA's proposed nonattainment area. Data presented for Eielson Air

Force Base showed that it is responsible for less than 5% of the NOx and SO_2 emitted within the Borough. Data provided for military training ranges located to the south of Fairbanks showed very limited activity during winter months.

Factor 2: Air Quality Data

ADEC has prepared several analyses of the $PM_{2.5}$ monitoring data collected in Fairbanks; this information was referenced in the State's nonattainment recommendations to EPA. The analysis documented temporal trends (i.e., summer versus winter) between 1999 and 2007, relations between $PM_{2.5}$ and individual chemical species, and used Positive Matrix Factorization (PMF) to assess source significance. All of the insight, however, was based on data collected at a single monitoring site in downtown Fairbanks. Recently, three sources of data were obtained that provide the first insight into the spatial extent of elevated concentrations:

- Data from a monitoring program conducted at Eielson Air Force Base between June 2004 and September 2005[6];
- Data from a monitoring program conducted at Fort Wainwright between February 2003 and January 2004[7]; and
- Monitoring data collected by the Borough this past winter at multiple sites within Fairbanks.

Presented below is a brief summary of findings from each new data source.

The Eielson monitoring program collected measurements of SO_2, NO_2, CO, ozone PM_{10}, and $PM_{2.5}$, as well as meteorological data on base, between June 2004 and September 2005. The 24-hour PM measurements were collected on a 1-in-6-day schedule with R&P Partisol 2000 filter samplers using a size-selective inlet. A comparison between the winter values collected at the base and FRM values from the Fairbanks downtown monitor on the same dates is presented in Table 3. It shows that on the days sampled between December 2004 and February 2005, all recorded concentrations were in the single digits, except for February 3, 2005, when values ranged between 11.1 and 11.3 $\mu g/m^3$. More importantly, on days when exceedances were recorded at the downtown monitoring site (highlighted in red), the values recorded at Eielson remained uniformly low. Based on these measurements, it appears that the emission levels at Eielson are insufficient to cause an exceedance of the ambient $PM_{2.5}$ standard even on days when high concentrations were recorded in downtown Fairbanks.

[6] Eielson Air Force Base Air Monitoring Program Annual Data Report, June 2004 – September 2005, prepared for the U.S. Air Force & Army Corps of Engineers by Hoefler Consulting Group, March 2006.
[7] Data Report for the Fort Wainwright Air Monitoring Network, Reporting Period, February 2003 – January 2004, prepared for Commander U.S. Army Center for Health Promotion and Preventive Medicine-Field Office Alaska by Battelle Eastern Science and Technology Center.

Table 3
Comparison Between Eielson and Downtown Fairbanks $PM_{2.5}$ Monitor Values Recorded During the 2004/2005 Winter
(ug/m^3)

Date	Eielson Monitors		Downtown FRM	Difference (downtown-main)
	Main	Co-located		
12/05/04	3.7	Invalid	21.1	17.4
12/11/04	4.1	Invalid	38.1	34.0
12/17/04	4.7	7.8	14.4	9.7
12/23/04	2.9	1.8	4.1	1.2
12/29/04	Invalid	7.4	31.9	24.5*
1/4/05	5.8	5.7	4.7	-1.1
1/10/05	6.9	9.5	28.9	22.0
1/16/05	5.0	7.9	40.6	35.6
1/22/05	6.1	6.6	32.7	26.6
1/28/05	8.8	8.8	29.2	20.4
2/3/05	11.3	11.1	60	48.7
2/9/05	7.9	7.8	23.8	15.9
2/15/05	4.6	5	15.7	11.1
2/21/05	6.9	6.7	34	27.1
2/27/05	3.7	3.3	6.1	2.4

*Downtown minus co-located

The Fort Wainwright monitoring program collected measurements of SO_2, NO_2, CO, PM_{10}, and meteorological data on base between February 2003 and January 2004. Measurements were collected at two locations—north and south of the primary source of emissions on the installation, which is a single coal-fired central heat and power plant (CHPP). The 24-hour PM measurements were collected on a 1-in-3-day schedule using a Tisch Environmental Model TE-6070 PM_{10} High Volume Air Sampler with a size selective inlet. A comparison between the winter values collected at the base and FRM values from the downtown monitor on the same dates is presented in Table 4.

While the values collected on base represent PM_{10} concentrations, which could be biased high for the purposes of $PM_{2.5}$, they are considered to be representative of $PM_{2.5}$ levels because the primary source of larger particles, fugitive dust, is not a contributor when the ground is frozen and covered with ice and snow. A review of the data shows that no exceedances of the ambient $PM_{2.5}$ standard were recorded during the winter months represented. It also shows that when an exceedance was recorded at the downtown monitor, the values at the base were almost 40 µg/m^3 lower. The data show that although concentrations are elevated relative to those observed at Eielson (for different dates), they are well below the ambient $PM_{2.5}$ standard. Thus, it appears that emissions on the base are insufficient to produce concentrations exceeding the ambient $PM_{2.5}$ standard even under conditions that cause exceedances at the downtown Fairbanks monitor.

Table 4 **Comparison Between PM_{10} Measurements at Fort Wainwright and $PM_{2.5}$ Measurements at Downtown Fairbanks Between February 2003 and January 2004 (ug/m^3)**				
	Fort Wainwright Monitors			
Date	North	South	Downtown FRM	Difference*
2/2/03	25.86	24.60	32.5	7.27
2/5/03	4.62	5.86	9.2	3.96
2/8/03	13.16	12.99	15.2	2.13
2/11/03	4.37	0.50	6.2	3.77
2/14/03	3.68	3.84	6.7	2.94
2/17/03	3.32	9.15	13.2	6.97
2/20/03	18.49	16.18	18.3	0.97
2/23/03	20.44	33.05	22.4	-4.35
2/26/03	22.36	21.75	22.8	0.75
12/05/03	9.76	11.34	30.1	19.55
12/11/03	13.15	12.83	21	8.01
12/17/03	8.62	6.93	8.7	0.93
12/23/03	6.09	8.34	20	12.79
12/29/03	5.17	4.99	9.7	4.62
1/04/04	3.87	3.92	14.6	10.71
1/10/04	7.43	7.83	14.4	6.77
1/16/04	14.40	14.30	54.2	39.85
1/22/04	5.87	3.67	11.1	6.33
1/28/04	24.85	24.68	25.5	0.73

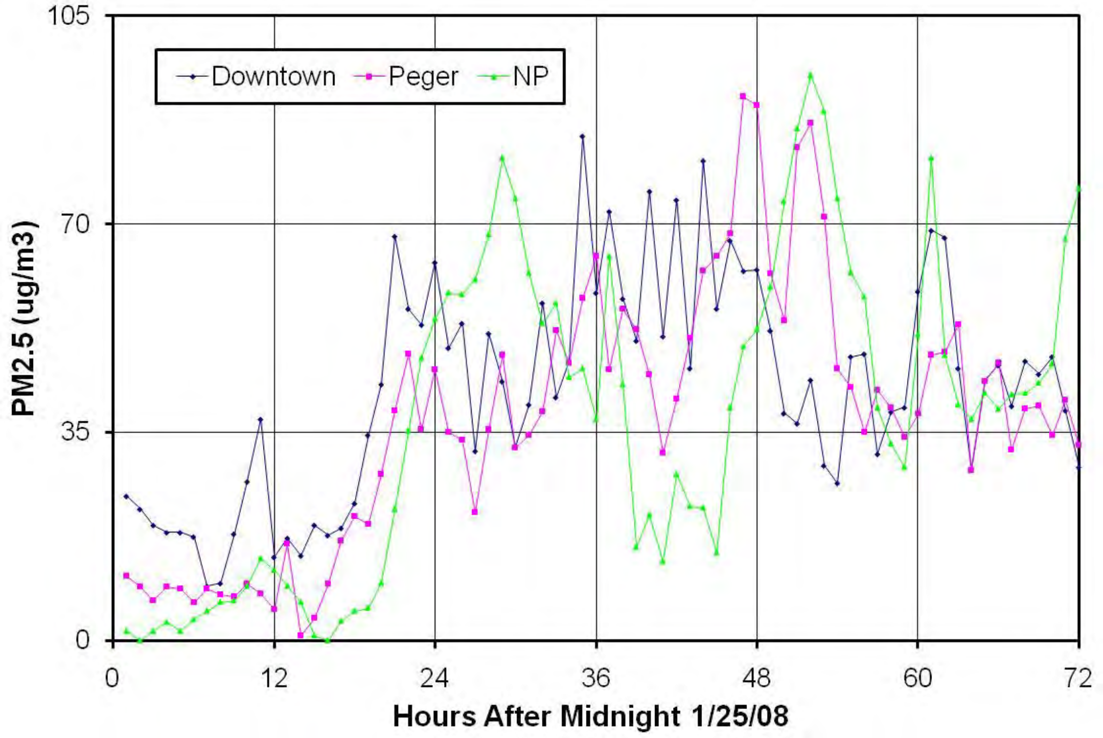
* Based on Downtown minus the mean of the north & south values.

The Borough placed $PM_{2.5}$ monitors at several fixed locations last winter and used a trailer equipped with a $PM_{2.5}$ monitor to collect data for 1-2 week periods at a number of locations. While equipment problems corrupted some of the measurements, good data were collected at three separate locations during an episode last winter:

- State office building, the long-term downtown monitoring site;
- Borough Transportation Department at Peger Rd. located approximately 2 miles to the southwest of the downtown monitor in a commercial/industrial area; and
- In a residential neighborhood located about 8 miles to the southeast of downtown.

A comparison of the hourly values recorded at those sites is presented in Figure 2. It shows that, despite the large distances between the monitors and the large differences in the localized source mix impacting the monitors, the concentrations recorded during the

Figure 2
Three-Site Comparison of Hourly BAM Measurements of $PM_{2.5}$
Downtown, Peger Road and North Pole Sites, 1/25/08 thru 1/27/08



onset of the inversion (between hours 12 and 24) at each monitor were strikingly similar, but lagged. After the inversion set up, the concentrations remained high, but were more discordant with each other. The key point seen in this chart is that elevated concentrations were recorded at multiple locations throughout the Borough during an episode. Because of the limited duration of the data collected, no insight is available into either the causes or the frequency of the occurrence.

Summary – Prior to last winter, the only source of $PM_{2.5}$ monitoring data was from the SLAMS monitor at the state office building in downtown Fairbanks. New monitoring data from other locations paint an inconsistent picture. The Eielson Air Force Base concentrations from an earlier winter remained well below the 24-hour $PM_{2.5}$ standard for an entire winter season and comparisons showed there were large differences between values recorded on base and those recorded at the downtown monitor. The Fort Wainwright values from an earlier winter show that, despite its close proximity to the downtown area, the values recorded over an entire winter season never exceeded the standard. The differences between the values recorded on base and those recorded at the downtown monitor, however, were much smaller. Data collected during an episode this past winter showed high concentrations at multiple locations. The military values suggest that concentrations throughout the region are not uniform and the data collected last winter during one episode show there maybe additional areas with higher concentrations. Clearly, the data do not support a conclusion and suggest the need for an intensive monitoring program, which is what ADEC and Borough are planning for the coming winter. A description of that program was included in a recent letter from the Borough to EPA [8] (to minimize the size of this document, this letter and its attachments are included in the zip file entitled "Fairbanks Resolutions").

Factor 3: Population Density and Degree of Urbanization

A review of the proposed nonattainment boundary found that large portions of unpopulated areas are included within the proposed nonattainment area. To illustrate the extent of the discrepancy, the Borough's Department of Community Planning prepared a chart of population density using 2000 census data. The chart, presented in Figure 3, shows most of the Borough is either unpopulated or has a density of fewer than 10 people per square mile. More importantly, the chart shows large areas to the south, east, northeast, and west that are unpopulated, but included within EPA's proposed nonattainment boundary. Information submitted by the military confirms that while a limited number of permanent facilities are located on the training ranges, no one resides in them, there are no paved roads, and operations during winter months occur infrequently.

Summary – Population density cannot be used to support the expansive nonattainment boundaries proposed by EPA. Large unpopulated areas are included within the proposed nonattainment boundaries in all directions except directly to the north.

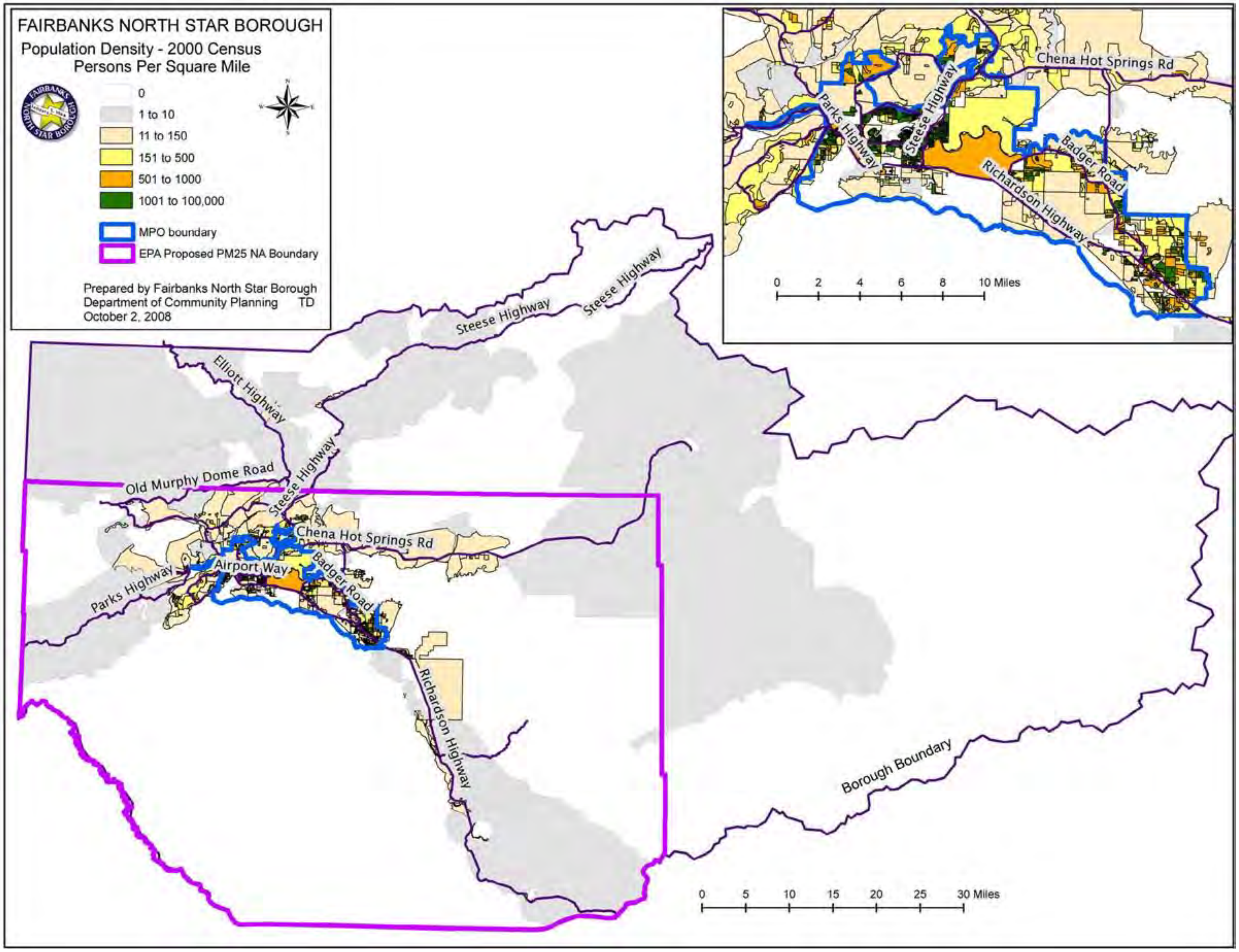
Factor 4: Traffic and Commuting Patterns

The annual VMT estimate reported by EPA for Fairbanks is significantly lower than values reported by the Northern Region of the Alaska Department of Transportation and Public Facilities (ADOT&PF). EPA reports a Borough wide value of 321 million miles in 2005; discussions with ADOT&PF[9] reported 723 million miles of travel in 2006. Roughly 58% of the travel (i.e., 418.7 million miles) occurred within the FMATS area. According to comments submitted by the ADOT&PF[10], EPA only reported VMT for a single category of roads (i.e., collectors) and failed to report travel for the rest of the road system.

With regard to commuting there are only three routes into/out of Fairbanks. The Parks Highway to the east (roughly 30 miles to the Borough border and an additional 10 miles to the nearest population center at Nenana), the Elliot Highway to the north (a distance of roughly 25+ miles to the EPA's recommended boundary and no obvious population center) and the Richardson Highway to the southeast (roughly 60 miles to the Borough

[8] Letter from Jim Whitaker, Major of Fairbanks to Robert Myers, Principal Deputy Assistant Administrator, Office of Air and Radiation, Subject "$PM_{2.5}$ Boundary", October 8, 2008
[9] Email from Jennifer Eason, Traffic Data and Forecasting Manager, Northern Region, ADOT&PF to Bob Dulla, Sierra Research, 10/15/2008.
[10] Letter from Leo von Scheben, Commissioner, ADOT&PF submitted to EPA Docket No. EPA-HQ-OAR—2007-0562, dated October 2, 2008

Figure 3
Fairbanks North Star Borough Population Density, 2000 Census



border and an additional 25 miles to Delta Junction). These distances combined with mountainous terrain and relatively low population of the nearest outside communities ensure that external commutes are not contributing to $PM_{2.5}$ concentrations reported in Fairbanks.

Summary – Despite the error in EPA's estimate of travel within the Borough, the conclusion with regard to potential impacts of commuter's is correct. The long distances to the Borough borders and low overall population density of the region ensures that external commutes are not contributing to elevated $PM_{2.5}$ concentrations in Fairbanks.

Factor 5: Growth

Long-term population growth in the Borough has been relatively stable at about 1% per year. As shown in Table 5, year-to-year variations can be quite significant, ranging from -3.2% to +4.0%. Data are shown for the entire Borough because EPA's proposed boundary includes most of the populated areas within the Borough, yet its analysis of growth focused only on data from the City of Fairbanks and North Pole. Given the limited area for growth within the City of Fairbanks, most of the growth in recent years has occurred in outside areas, as demonstrated in the difference between growth rates seen in the City of Fairbanks and North Pole (i.e., 3% versus 16% between 2000-2006).

Table 5
Trends in Fairbanks North Star Borough Population Between 1996 and 2007

Year[a]	Population	Year-to-Year Change Relative to 1996
1996	81,883	-
1997	82,064	0.2%
1998	83,045	1.2%
1999	83,773	0.9%
2000[b]	82,840	-1.1%
2001	83,261	0.5%
2002	84,749	1.8%
2003	82,160	-3.2%
2004	85,453	4.0%
2005	87,704	2.7%
2006	87,766	0.1%
2007	90,963	3.9%

[a] Alaska Department of Labor and Workforce Development
[b] U.S. Census Bureau

The data presented in Table 5 demonstrate that despite the differences seen between these two areas, the long-term growth rate throughout the populated areas of the Borough has been stable on a long-term basis, roughly 1% per year, but erratic on a year-to-year basis.

As noted in the discussion of traffic and commuting patterns, the VMT values presented for Fairbanks are incorrect and only represent that portion of travel from one category of roads (i.e., collectors). Thus, the data presented are not representative of overall travel trends within either the FMATS area or within the Borough. Discussions with ADOT&PF staff responsible for travel forecasts within Fairbanks indicate that Borough wide estimates are not usually broken out within the northern region. Similarly, trends in estimates of FMATS values are complicated by expansions in the boundary over time. Thus, at present no uniform set of travel data is available to track trends over time. Despite this limitation, the population growth data provides insight into growth rates that have occurred within the Borough.

Summary – The data presented above demonstrate that the long-term growth rate throughout the populated areas of the Borough has been stable on a long-term basis, roughly 1% per year, but erratic on a year-to-year basis. This insight confirms there is no need to expand the nonattainment boundaries to ensure that emissions from projected growth within the Borough are captured and controlled.

Factor 6: Meteorology

The continuous Beta Attenuation Monitor (BAM) $PM_{2.5}$ monitor located in downtown Fairbanks, Alaska (Figure 4) measured exceedances of the current daily $PM_{2.5}$ standard (35 µg/m^3) on 11 days[*] during a 21-day period between January 23, 2008, and February 12, 2008. During the same period, a moveable trailer equipped with a BAM recorded two exceedances of the 24-hour $PM_{2.5}$ standard while it was located in North Pole. Meteorological data for the entire period were collected from the following three locations shown in Figure 4:

1. Fairbanks International Airport (Airport) – surface and upper-air data;
2. Fort Wainwright Army Air Field (Fort Wainwright) – surface data, available only on weekdays between 6 a.m. and 10 p.m.; and
3. Eielson Air Force Base (Eielson) – surface data.

The time series data from the above meteorological stations, as well as $PM_{2.5}$ data from the two monitors mentioned above, are shown in Figures 5 through 7.

The 21-day period began with temperatures ranging from 10-20° Fahrenheit (F) and west-northwesterly winds between 10-20 knots across the three meteorological stations

[*] A recent correlation analysis between data collected by the BAM and adjacent FRM values found a 32% bias in the BAM values. At this time the data has not been corrected to assess the impact of this bias on reported exceedances. Therefore, it is possible that exceedances are over-reported in this document.

evaluated, and the 24-hour average $PM_{2.5}$ concentration in downtown Fairbanks was low, about 10 µg/m^3. However, abrupt surface temperature cooling across the region on January 23–24 and again on January 25–26, as evidenced by the dark blue line in Figures 5–7, led to increased residential heating and associated emissions and the formation of a strong low-level temperature inversion that trapped emissions near the surface. Also, wind speeds, shown in red on each of the graphs, became calm (< 3 knots or 3.5 miles per hour) at all three meteorological monitoring locations, producing stagnant conditions. The winds did not increase until February 10, fifteen days later and after eleven $PM_{2.5}$ 24-hour ambient standard exceedances had been recorded. On several of the high $PM_{2.5}$ days, the Airport and Eielson sites did measure brief periods of non-calm winds; however, the winds remained less than 5 knots and did not produce any significant pollutant transport due to their short duration and infrequent nature.

The most dominant meteorological parameter during the $PM_{2.5}$ episode was the surface air temperature, which had a minimum of -40°F or less on all but two of the exceedance days. On the remaining two exceedance days, January 29 and 30, temperatures still dropped to between -20°F and -25°F at all three stations. However, on the days when the temperature increased (January 25, 28, and 31, and February 1, 2, 11, and 12), irrespective of the typical diurnal heating seen during the daylight hours, $PM_{2.5}$ concentrations dropped below the ambient $PM_{2.5}$ standard threshold, even with the winds remaining calm, due to increased vertical mixing in the boundary layer. The combination of continuous, extended periods of very cold temperatures and calm winds, especially from February 4 through the 10, produced the ideal meteorological conditions for high $PM_{2.5}$ concentrations.

Surface wind patterns during the 21-day period (excluding the times when the winds were calm) could be split into two main categories: (1) synoptically driven winds out of the west-northwest, shown by the thin green line in Figures 5-7 at the beginning and end of the analysis period and depicted by the higher speed, lower frequency wind classes on the left side of the wind roses in Figures 8-12; and (2) mesoscale drainage flows, mainly due to cold air descending down off the mountains surrounding the region on the western, northern, and eastern sides. Local, mesoscale air flows were also characterized by flow along the Tanana River, which was southeasterly (moving from the southeast to the northwest) near Eielson AFB (Figure 8); east-northeasterly near Fort Wainwright (Figure 9); and north-northeasterly near the Airport (Figure 10). The resulting counter-clockwise flow along the river could have transported air and pollutants across the region; however, any air over the river remained there and did not drift into the neighboring cities due to the prevailing land drainage flow that descended toward and merged into the river channel air flow.

To further understand air flow within the region, data from the upper-air soundings launched from FIA were evaluated at the surface and at a height of 200–300 meters, or the closest height available. The data plotted in Figures 11 and 12 are slightly different from the other wind roses because, instead of hourly data, they show data collected by the twice-daily upper-air soundings sent up at approximately 3 a.m. and 3 p.m. Alaska Standard Time (AKST). The surface level plot (Figure 11) is similar to the plot from the Airport surface station shown in Figure 10. Differences between the two can be attributed to the sampling frequency and duration, where the surface station data are hourly and averaged over two minutes and the sounding data are twice-daily and instantaneous, due to the rapid ascent of the balloon. The aloft data (Figure 12) are from 200–300 meters (656–984 feet) above ground level and give an indication of the air flow above the shallow, nocturnal temperature inversion. As expected, the winds are stronger at the higher elevations, but, like at the surface, the dominant wind direction is northeasterly. In addition, the winds were calm over 40% of the time and those periods coincided with the high $PM_{2.5}$ concentration days, indicating that little or no pollution transport occurred in aloft layers up to 1,000 feet, supporting a conclusion that only local emission sources are contributing to the exceedances.

Another feature of the surface and upper-air wind roses is that four out of the five do not show any significant amount of southerly winds during the $PM_{2.5}$ episode, indicating that emissions from activities on the military range to the south of Fairbanks and the Tanana River could not have been transported into the metropolitan area or affected $PM_{2.5}$ concentrations. The only exception is the wind rose for Eielson AFB, which indicated occasional, short-duration periods of south-southeasterly winds; however, because it is on the eastern side of the region, the winds there have no bearing on the potential transport of air from the range.

<u>Summary</u> – High $PM_{2.5}$ days in Fairbanks are the result of very cold surface temperatures and shallow temperature inversions, calm winds creating stagnant conditions and inhibiting the transport and/or dispersion of pollutants, and local emissions in each community simultaneously producing localized air pollution increases and $PM_{2.5}$ concentrations high enough to exceed the standard in some areas. These factors indicate that the emission sources contributing to high pollution concentrations in Fairbanks are fairly localized and that the nonattainment boundary should be constrained to the populated areas where elevated concentrations occur. The large distances between the military ranges and the populated areas of Fairbanks, combined with an absence of southerly winds during $PM_{2.5}$ episodes, demonstrate that the limited emissions from these facilities do not contribute to exceedances recorded in Fairbanks. Similarly, data collected at Eielson show there is no transport of its emissions into Fairbanks prior to or during episodes except for brief periods of southeasterly flow that is shown to be part of drainage flow along the Tanana. Data collected at Fairbanks International Airport demonstrate that the dominant flow prior to and during episodes is from the northeast and there is little evidence of any flow from the west. These findings demonstrate that EPA's expansive boundaries are overly conservative and unwarranted and provide a basis for redefining the boundaries to the south, east, and west.

Figure 4
Map of Fairbanks Meteorological and $PM_{2.5}$ Monitoring Sites

Figure 5
Meteorological and $PM_{2.5}$ data for Fairbanks International Airport

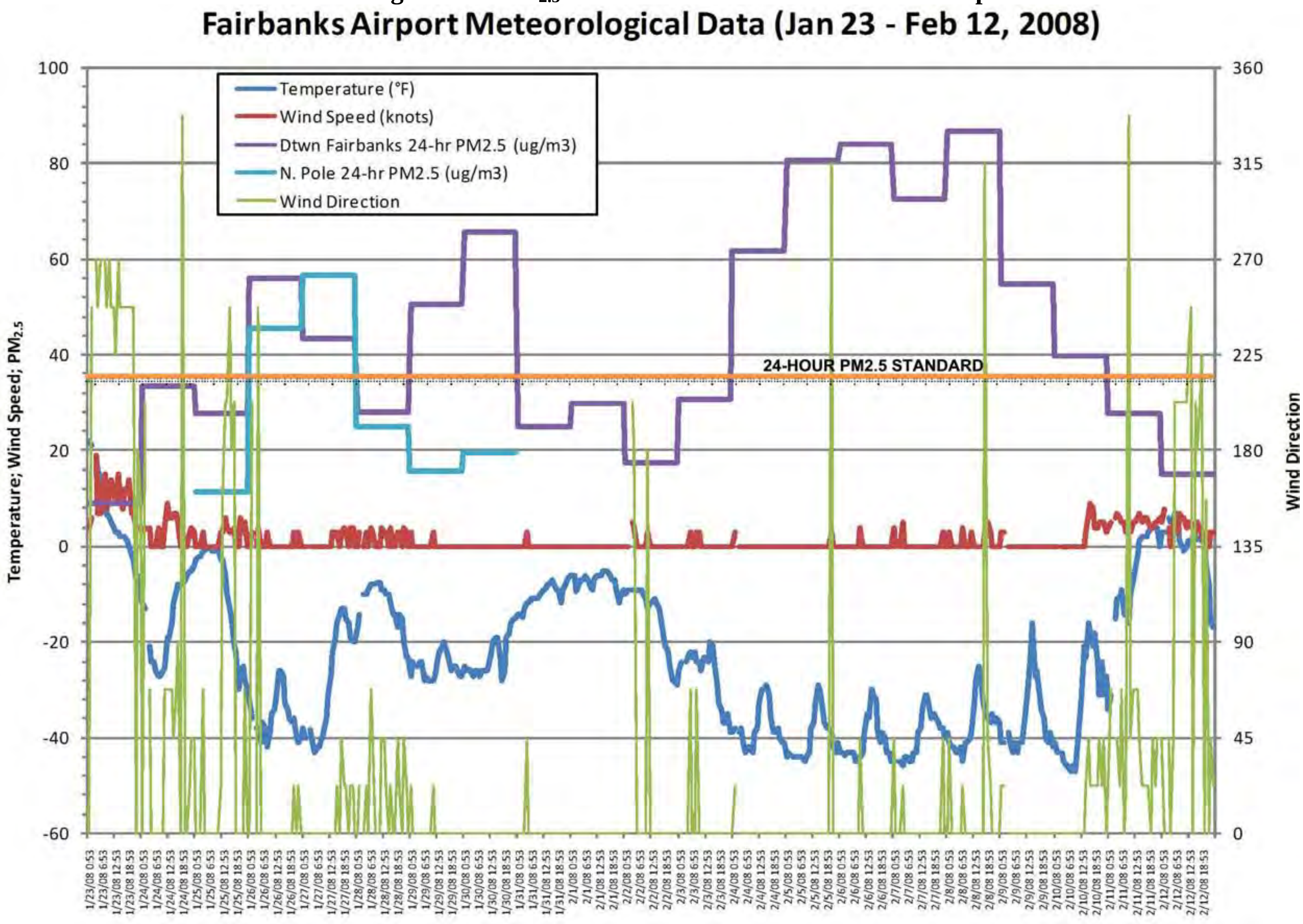


Figure 6
Meteorological and $PM_{2.5}$ data for Fort Wainwright Army Air Field

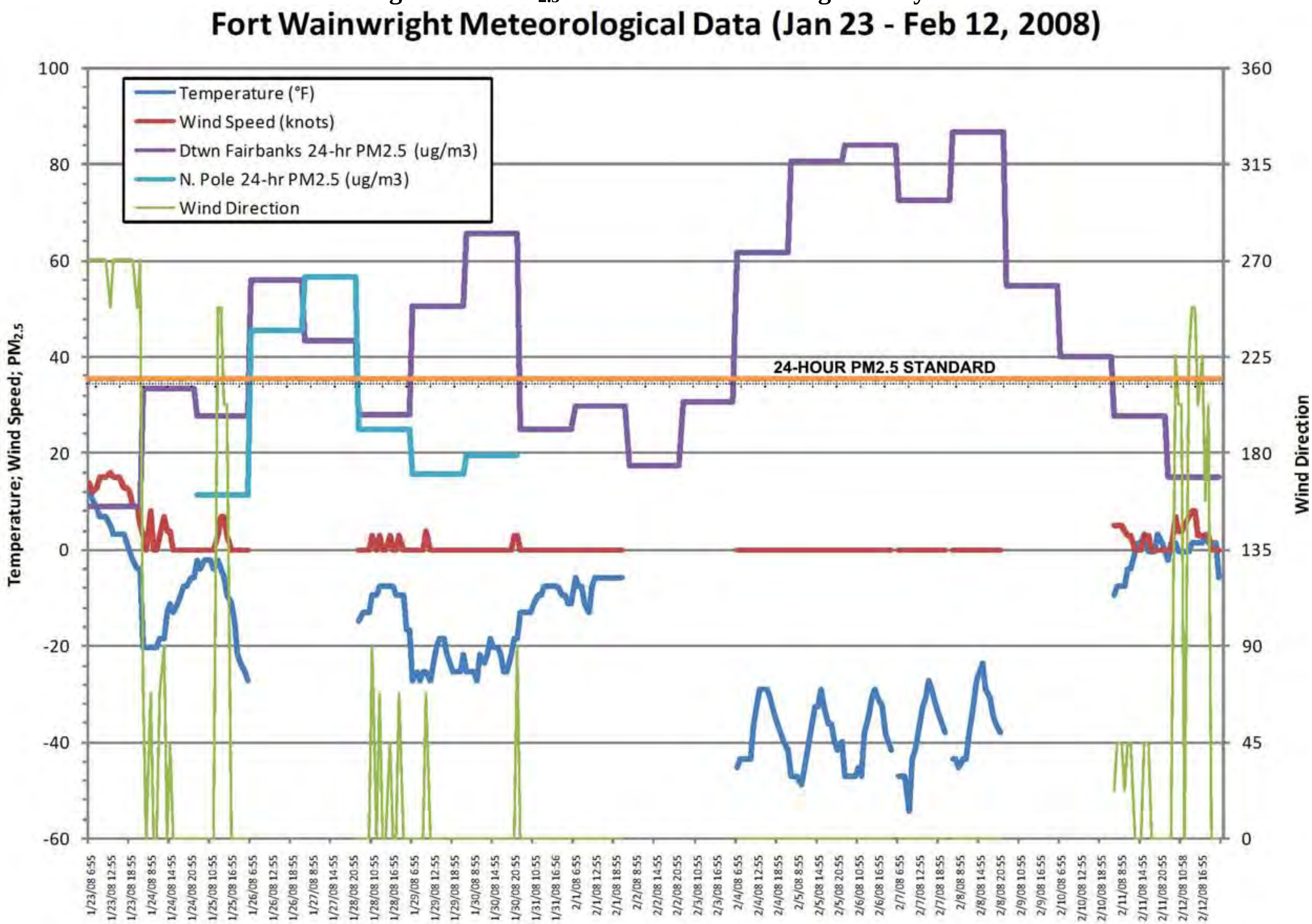


Figure 7
Meteorological and $PM_{2.5}$ data for Eielson Air Force Base

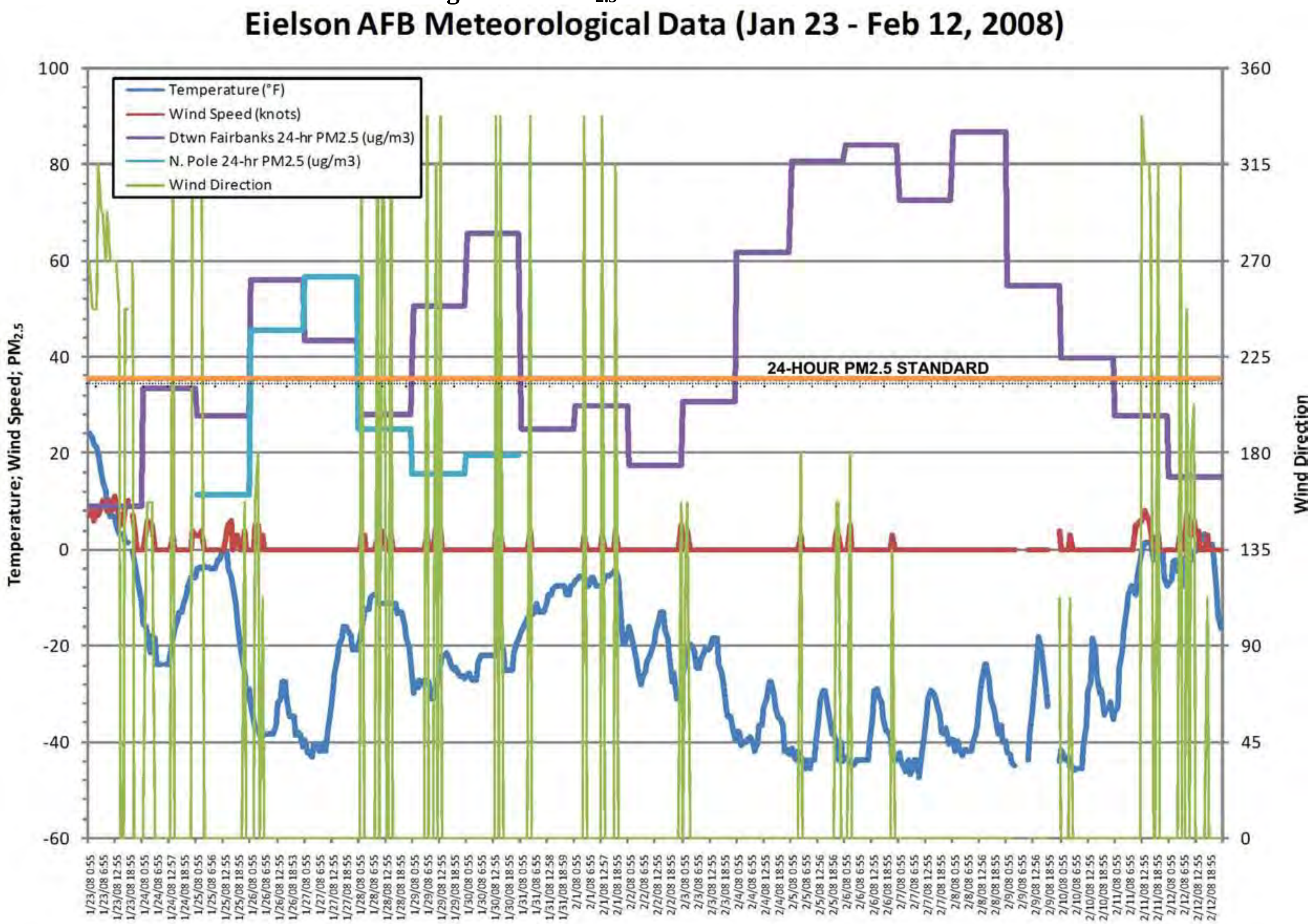
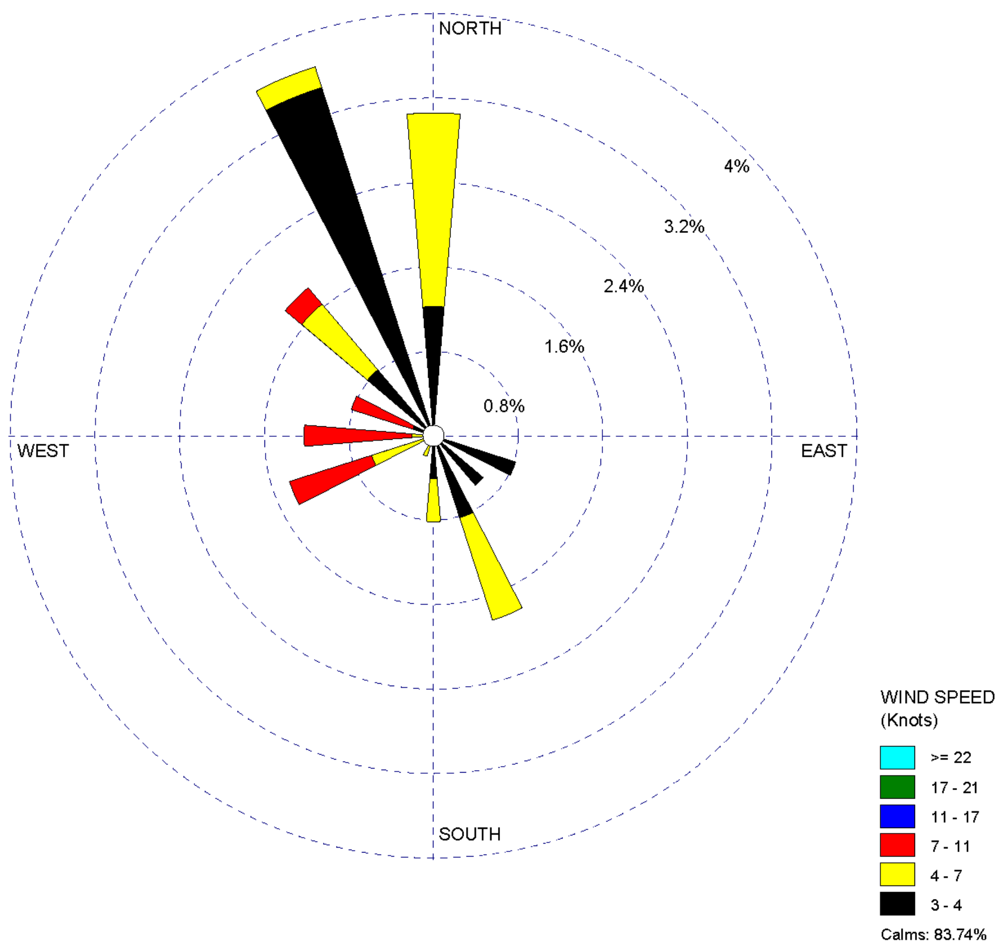


Figure 8
Wind Rose for the Surface Meteorological Station at the Eielson AFB

WIND ROSE PLOT:
FAIRBANKS/EIELSON AFB

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:
- Surface data
- Calm = WS<3 knots

DATA PERIOD:
2008
Jan 23 - Feb 12
00:00 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
83.74%

TOTAL COUNT:
492 hrs.

AVG. WIND SPEED:
0.83 Knots

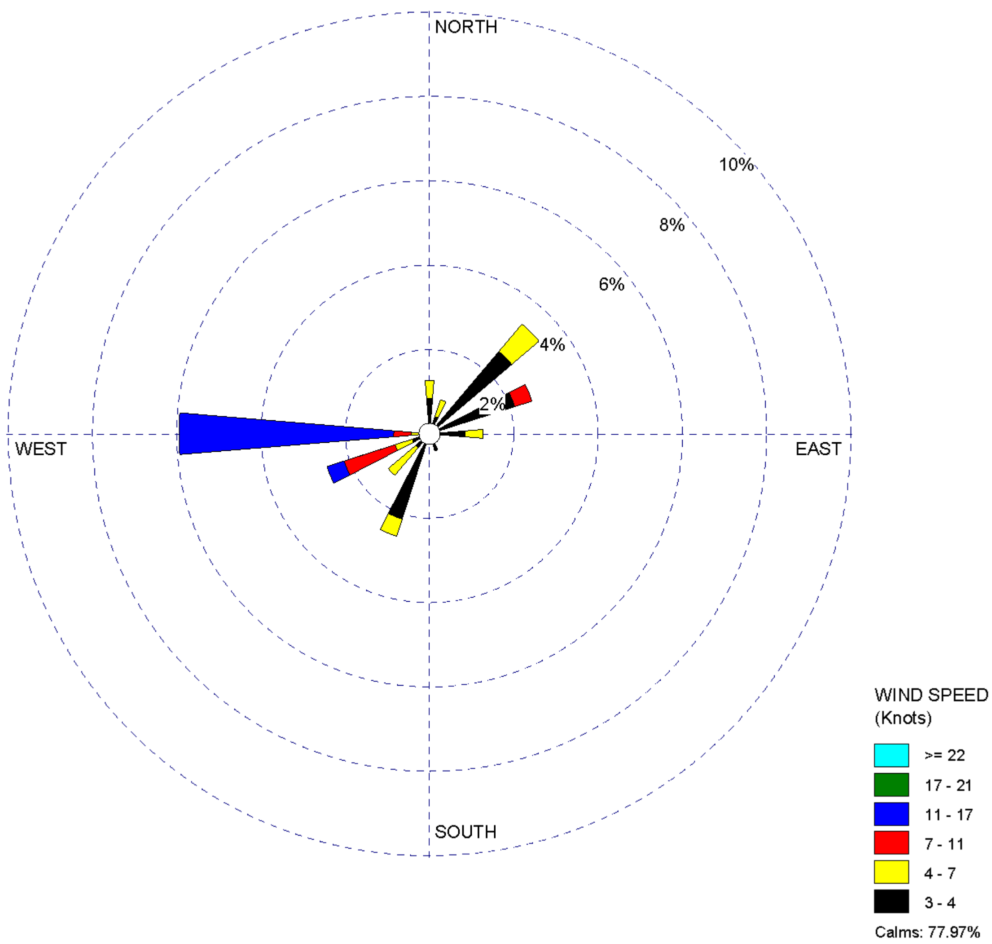
DATE:
10/15/2008

PROJECT NO.:

Figure 9
Wind Rose for the Surface Meteorological Station at the Fort Wainwright AAF

WIND ROSE PLOT:
FAIRBANKS/FORT WAINWRIGHT

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:
- Surface data
- Calm = WS<3 knots

DATA PERIOD:
2008
Jan 23 - Feb 12
00:00 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
77.97%

TOTAL COUNT:
236 hrs.

AVG. WIND SPEED:
1.53 Knots

DATE:
10/15/2008

PROJECT NO.:

Figure 10
Wind Rose for the Surface Meteorological Station at the Fairbanks International Airport

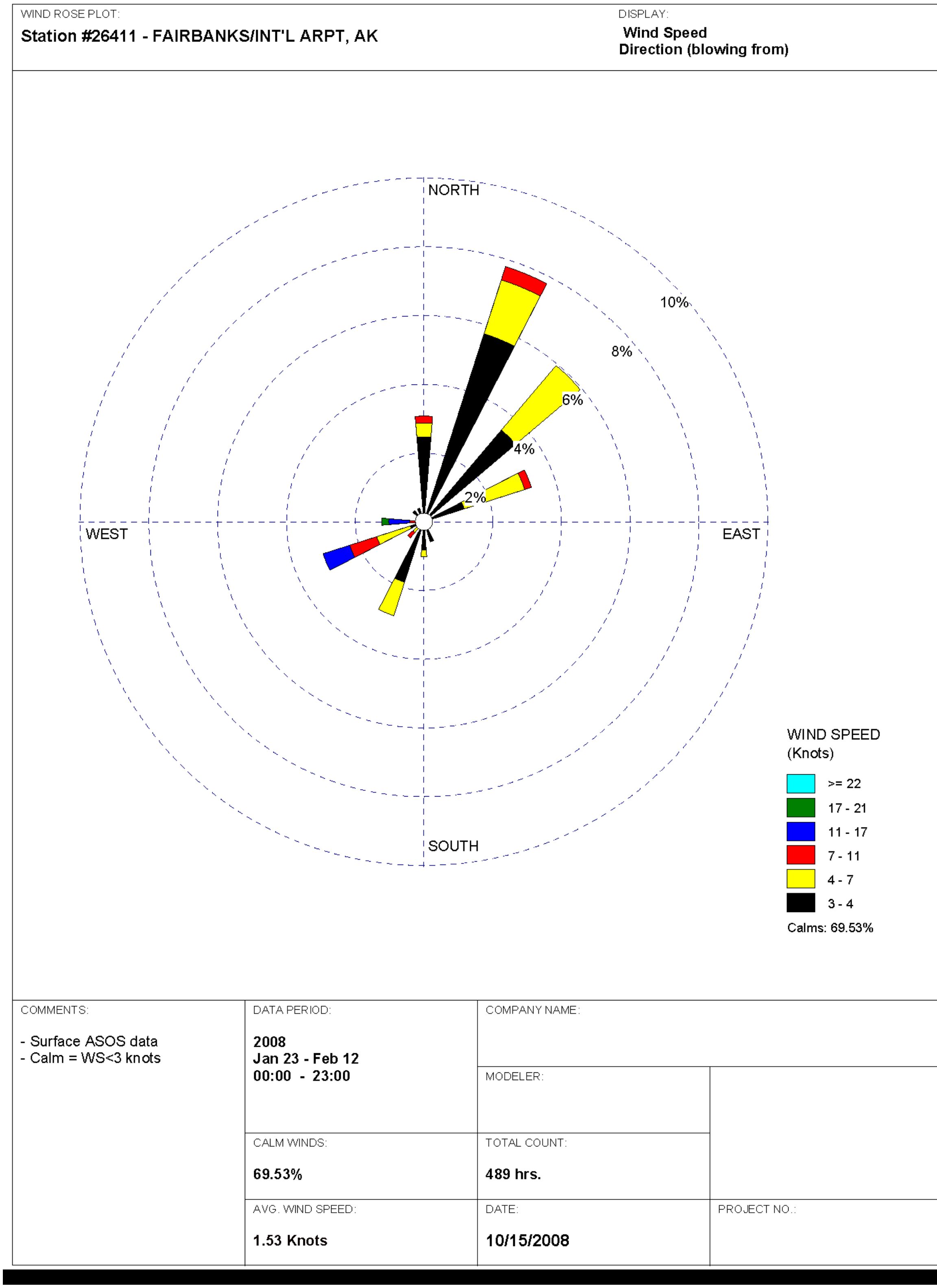


Figure 11
Wind Rose for the Surface Level of the Fairbanks International Airport Upper-Air Sounding

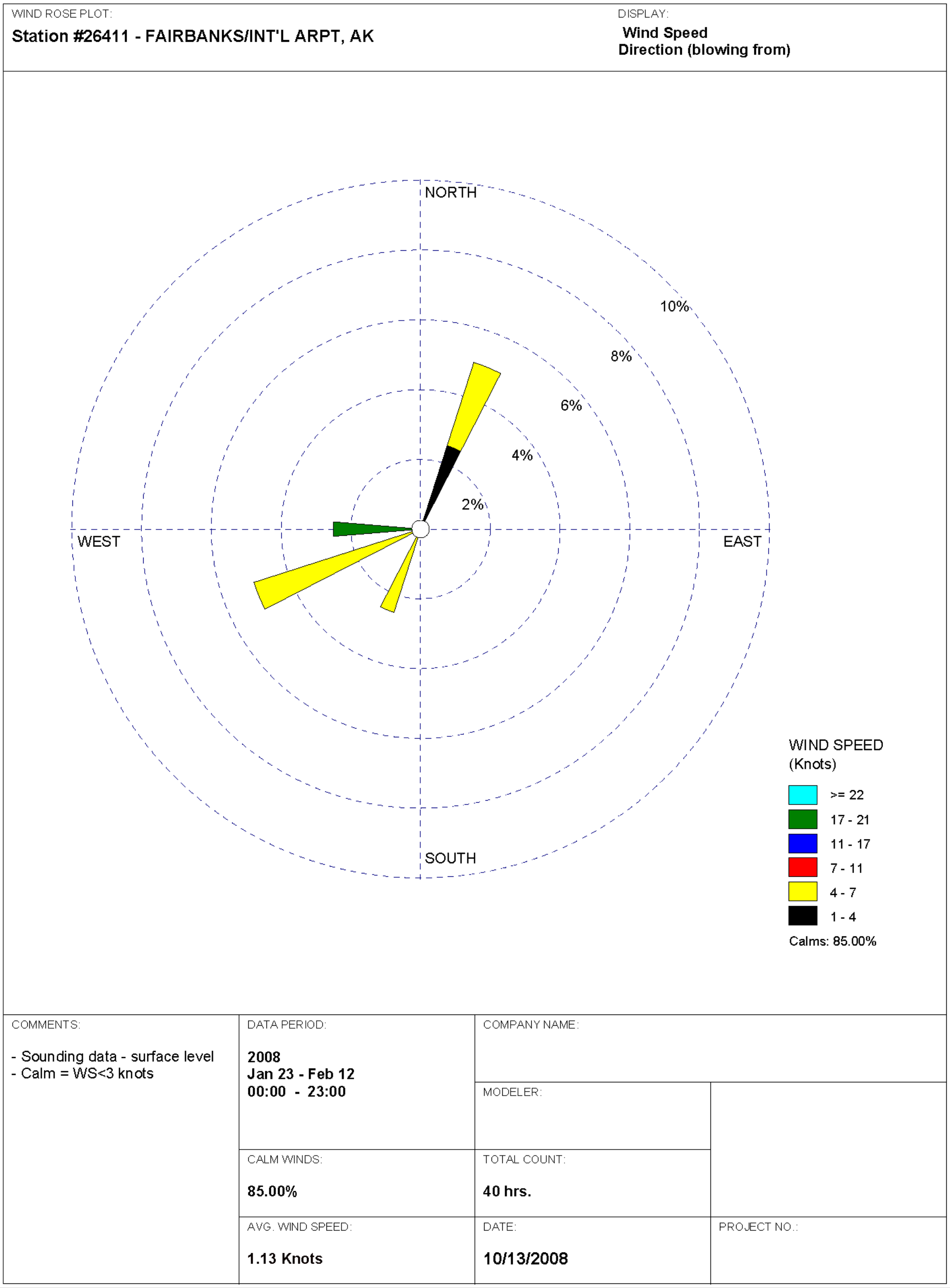
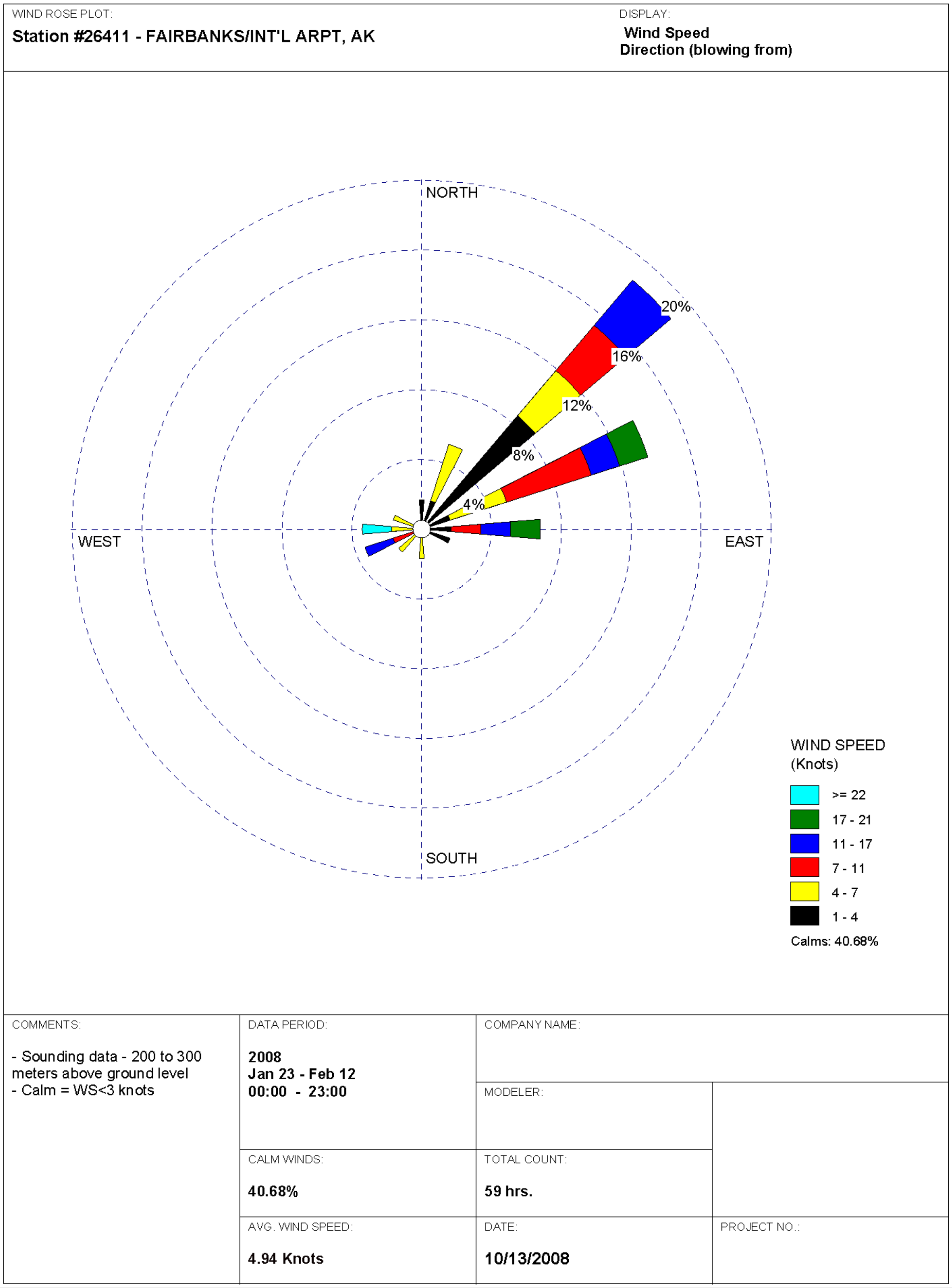


Figure 12
Wind Rose for the 200–300 Meter Level of the Fairbanks International Airport Upper-Air Sounding



Factor 7: Geography and Topography

Fairbanks, Alaska is located at an elevation of approximately 440 feet above sea level (ASL) and is bordered on the west, north, and east by mountain ridges, such as Ester Dome and Cranberry Ridge (Figure 13), ranging in height from 1,000 feet to nearly 2,500 feet; on the south, it is bordered by the Tanana River Flat. The mountains create a clear barrier between the Fairbanks area and neighboring valleys, limiting the extent to which emissions in those valleys could impact Fairbanks. This fact is especially relevant under strong, low-level temperature inversion conditions that limit the vertical mixing of air to hundreds of feet, well below the nearest ridge heights. However, because of its low elevation relative to its surroundings, Fairbanks is the pooling area for some of the drainage flows coming down out of the mountainous regions, as indicated by the red lines in Figure 13. As a result, some valleys to the west and north of Fairbanks, namely Ester Valley and Goldstream Valley, could have an impact on Fairbanks. Valleys beyond Ester and Goldstream, though, are separated by ridges of at least 1,500 feet, which are more than sufficient to prevent air flow between those distant valleys and the valleys proximate to Fairbanks that drain into its basin.

Another type of drainage flow shown in Figure 13 is that along the Tanana River. Due to gradual descent in elevation from the east toward the west, air above the river will tend to flow in the same direction as the river and draw air from the adjacent land.

The wind flow arrows shown in Figure 13 are a depiction of typical flows that develop under strong high pressure patterns, when large-scale, synoptically forced winds are not a factor and wintertime $PM_{2.5}$ concentrations are most likely to increase. It is important to note that even with the drainage flows, winds in the predominately flat areas of Fairbanks and areas to its east can be calm to light and variable. As a result, the drainage flows can be limited to the valleys and mountain faces and may not extend much beyond the base of the mountains.

Summary – The mountains to the west, north, and east of Fairbanks create clear barriers from neighboring valleys which limit the exchange of emissions. However, because of its low elevation relative to the valleys located to the west and the north, it is likely that drainage flows coming out of those valleys could have an impact on Fairbanks. Conversely, drainage flow from mountainous areas to the east of Fairbanks are not likely to have much of an impact on Fairbanks because emissions in those areas are minimal to zero and the winds commonly decrease to calm once the flows exit the valleys and spread out across the flat, open areas.

Figure 13
Topography and Drainage Flows in Fairbanks Area

Factor 8: 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. The area encompasses 7,361.0 sq. miles of land and 77.8 sq. miles of water (an area larger than either Delaware or Rhode Island). 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, FMATS (Fairbanks Metropolitan Area Transportation System), whose boundary includes both Fairbanks and North Pole and extends further into population areas within the vicinity of both communities.

Figures 14 through 16 are maps of the borough, cities, and FMATS boundaries. Information submitted by the military shows that it has jurisdiction over the large training facilities located to the south and east of Fairbanks.

Figure 14
Fairbanks North Star Borough

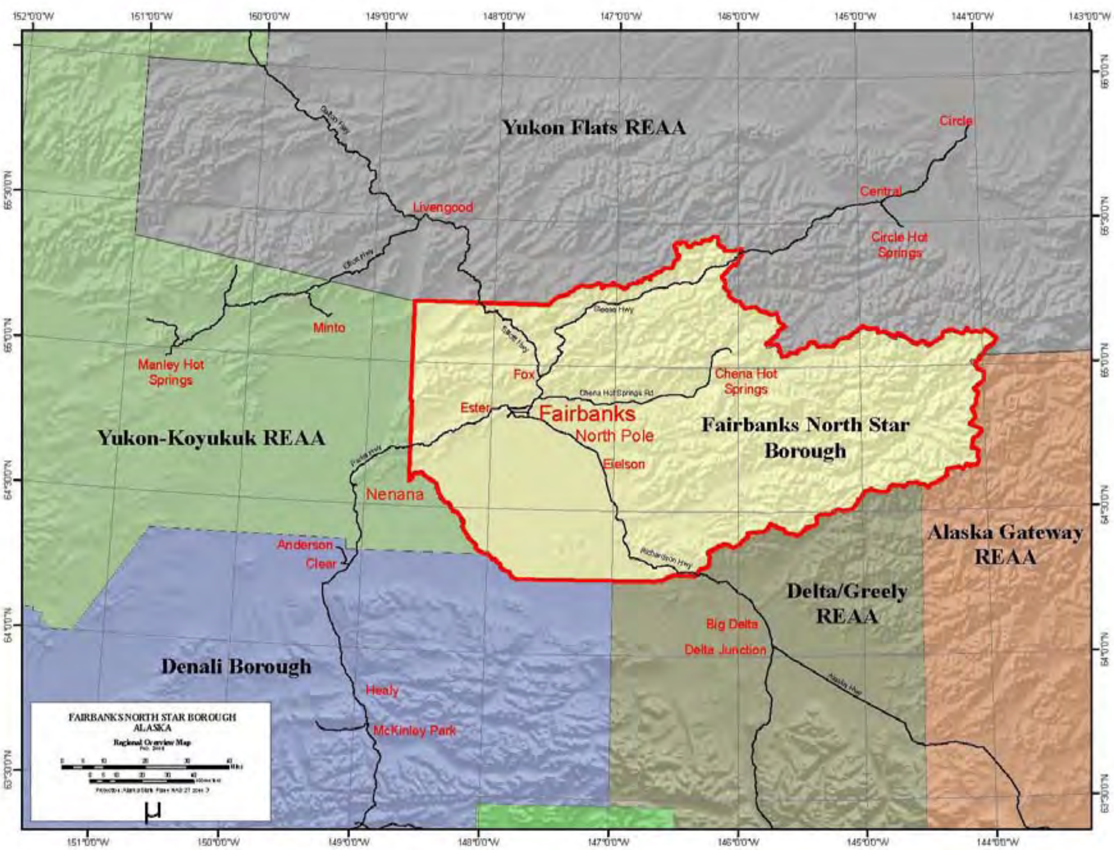


Figure 15
City Boundaries within the Fairbanks North Star Borough

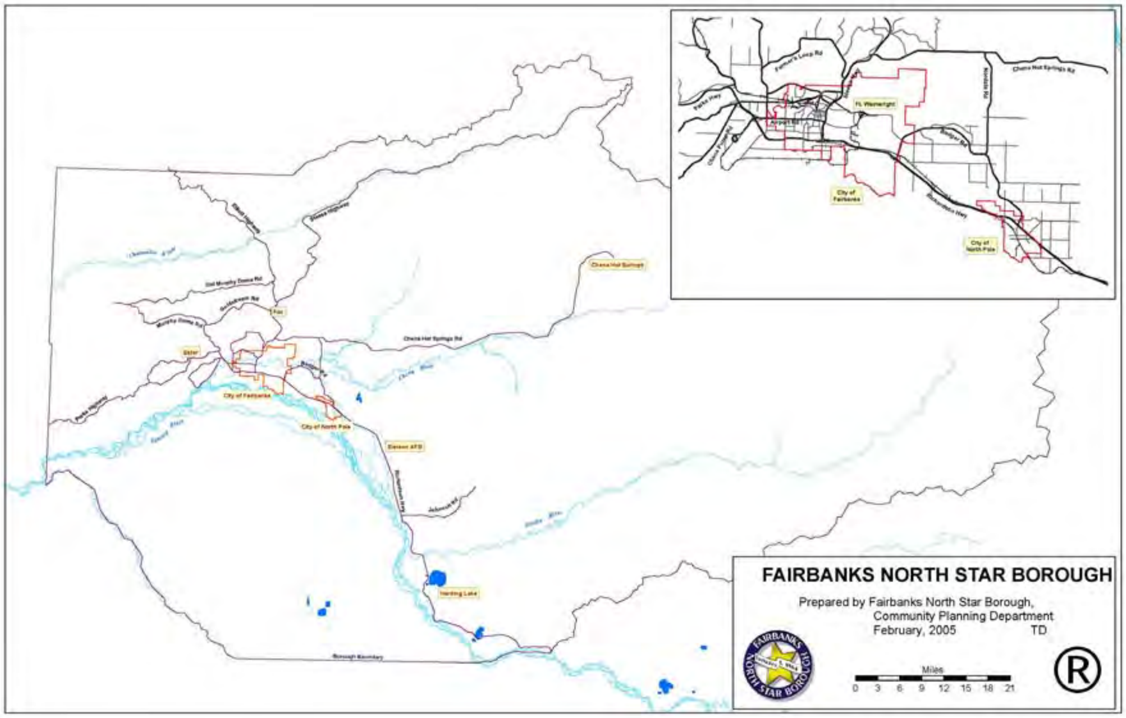
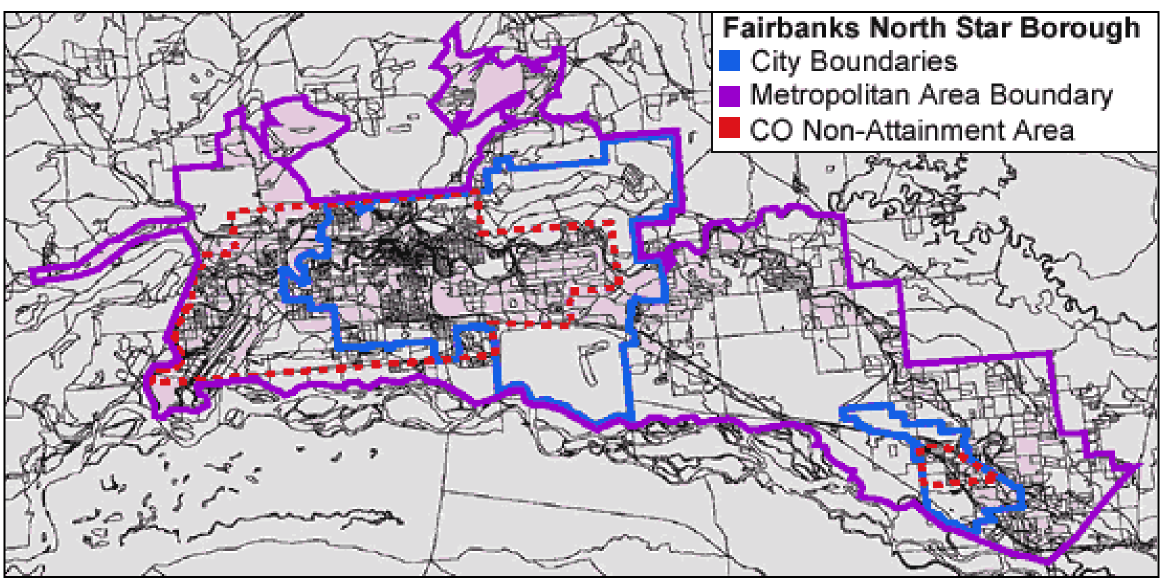


Figure 16
FMATS Boundary



Summary – The nonattainment boundaries proposed by EPA encompass several distinct jurisdictions, including FMATS; the cities of Fairbanks, North Pole, Ester, and Fox; the military bases; and the military training facilities. Many of these locations are not currently subject to existing Borough emission control measures.

Factor 9: Level of Control of Emissions Sources

While no Fairbanks area sources have been specifically targeted for control of fine particulates at this time, there are some existing controls in place, as summarized below.

- Major stationary sources are controlled through the Alaska Department of Environmental Conservation's permitting program. With regard to particulate matter, it should be noted that the coal-fired power plants in Fairbanks are controlled with bag houses.

- Mobile sources are controlled by federal fuel and emission rules that limit particulate matter and pre-cursor pollutants. It is not known how effective these controls are at the extreme cold temperatures found in Fairbanks, but improvements should continue to be made as the vehicle fleet turns over.

- Fairbanks has an extensive network of electrical plug-ins powered at 20° F that allows citizens to use engine block heaters to keep their motor vehicle engines warm during cold temperatures. This program significantly reduces CO emissions from cold starting vehicles, but it is not known how much benefit may exist for fine particulate emissions from the use of engine pre-heating.

- The Fairbanks North Star Borough operates a transit program that provides some benefits through reduced VMT from mobile sources.

- A local wood-burning control program exists under the carbon monoxide maintenance plan. To the extent that high $PM_{2.5}$ days occur on days with high CO concentrations, this control program could provide some benefit. It is more likely that a different program will be needed to fully address $PM_{2.5}$ emissions from wood-burning stoves.

- Open burning is prohibited from November 1 through the end of February within the areas of the Borough designated as Urban, Urban preferred commercial, Light or Heavy Industrial, or Perimeter area, with camp fires being an exception.

- Prescribed fire for burns over 40 acres is managed by the Alaska Department of Environmental Conservation through a permitting process and a smoke management plan.

- The Alaska Railroad switched to ultra low sulfur Diesel fuel in 2007, 5 years in advance of EPA's 2012 mandate.

Summary – Fairbanks, ADEC, and the military have implemented controls targeted at other pollutants that provide reductions in $PM_{2.5}$ emissions.

Overall Summary and Recommendations

The local information used in the nine-factor analysis presented above contradicts much of the evidence EPA used to expand the boundary proposed by the State. Presented below is a summary of why EPA's proposed boundary should be changed; it is organized by direction.

- North – The region between the FMATS boundary and EPA's proposed boundary contain areas of relatively high population density (up to 500 people per acre). No point sources however are located in this region. Meteorological data shows winds to be predominantly out of the east-northeast that are impacting Fairbanks prior to and during $PM_{2.5}$ episodes. The topographic data shows drainable flow from the Goldstream Valley could impact Fairbanks. While this information largely supports the northern boundary recommended by EPA, revisions are needed to address the location of specific neighborhoods.

- South – The entire region between the proposed southern boundary and the Tanana River is unpopulated. There are no paved roads in this region; no point sources are located in this region. Emissions data provided for the Blair Lakes facility, which is located approximately 23 miles south of Fairbanks represents a insignificant fraction of the NOx and SO_2 inventory. Data provided for the other ranges shows activity during winter months is limited and sporadic. Meteorological data show that winds prior to and during an episode are never from the south. In summary, there is no evidence supporting the southern boundary recommended by EPA. The data suggest the need for a substantial revision of the boundary to the north.

- East – Large areas of the region are unpopulated. Eielson is the only area east of North Pole with any population density and it is shown to be less than 150 people per acre. Monitoring data collected at Eielson showed winter $PM_{2.5}$ concentrations consistently in the single digits and significantly below concentrations recorded in downtown Fairbanks. Emissions data show the base's share of the NOx and SO_2 inventory to be below 5%. Surface meteorological data show there is no transport of base emissions into either North Pole or Fairbanks prior to or during episodes except for brief periods of southeasterly flow which is shown to be part of drainage flow along the Tanana River. Data on winds aloft is limited to soundings at Fairbanks International Airport, which shows winds to be predominantly out of the east-northeast with little flow from the southeast. Thus, the available data do not show an impact from Eielson's power plant emissions. Collectively, these data do not support the eastern boundary proposed by EPA. Instead, the data support a substantial revision of the boundary to the west.

- West – Large areas north of the Tanana and west of Fairbanks located within EPA's proposed nonattainment boundary are unpopulated. No point sources are located in the area between the western boundary of the FMATS region and western boundary proposed by EPA. Meteorological data collected at Fairbanks International Airport shows the dominant flow prior to and during episodes is from the northeast with little evidence of flow from the west. Higher density populated areas, however are located outside of the western FMATS boundary. Topographical data suggests drainage flow from Ester Valley could impact Fairbanks. Overall, the data provide no support for EPA's recommended western boundary and suggest the need for a substantial revision of the boundary to the east.

In light of the information, presented above, the State in concert with the Borough developed a recommended nonattainment boundary. The starting point for these recommendations was the FMATS area. Revisions to that boundary are primarily based on consideration of population density, meteorology, terrain, emissions and the lack of growth. Figure 17 displays the recommended nonattainment boundary. It presents both the FMATS boundary and the proposed revisions. As can be seen the bulk of the revisions are to the west and north, with limited changes to the east and no changes to the south. To simplify the review and discussion of the basis for the proposed boundaries, Figure 18 presents the final recommended boundary without the FMATS distinction. Also, included in Figure 18 are the names of specific landmarks impacting the selection of the boundary. Both figures also include information on terrain.

In addition to the factors noted above, care was taken to ensure the boundary is consistent with ownership (i.e., lots were not split) and that entire neighborhoods were included within the proposed nonattainment area unless they were divided by geographical features (e.g., ridgeline) that distinguished their potential to impact Fairbanks.

Starting with the south, the proposed boundary is consistent with the FMATS boundary, which is located just to the north of the Tanana River. The eastern edge follows the FMATS boundary, which excludes Eielson, but is expanded to include populated areas adjacent to Chena Lakes, east of Nordale Road and north of Badger Road. The areas excluded to the east include undeveloped areas and swamp land. Some of the excluded areas also appear to include populated areas, however, a discussion with the Borough demographer indicated that these were artifacts of arbitrary census boundaries and in fact no one lived in those locations (because the density reflects the average of the area represented, not the location of where people lived). The northern end of the eastern boundary is selected to incorporate the higher density valley to the west of Gilmore Dome but to exclude communities farther to the east. The low population density of these communities and distance from the higher density areas of Fairbanks and North Pole is seen to limit their potential impacts despite the predominant northeast wind flow.

Recognizing the potential of Goldstream Valley to impact Fairbanks, the FMATS boundary was expanded well to the north to include all areas with the potential to contribute to the drainage flow. The northern boundary is not located at the top of the ridge separating the Chatinika Valley from the Goldstream Valley as recommended by EPA. Instead the northern edge of the populated areas was selected, hence the jog in the middle of the northern boundary. To the west, the FMATS boundary was expanded to include the higher population density areas with the potential to contribute drainage to Goldstream Valley. This includes the area to the east of Ester Dome. The areas along Murphy Dome Road further to the west were excluded because of the combination of low population density, distance from the higher density populated areas and prevailing meteorology. The southwestern FMATS boundary was expanded to include Ester Valley. This area, located to the south of Ester Dome and East of Chena Ridge is seen as having the potential to contribute to drainage into Fairbanks.

Fairbanks residents will be concerned about the size of the proposed nonattainment area. Many of the proposed areas are low density and located a considerable distance from downtown Fairbanks. These areas will be perceived as having no air quality problems since there is no monitoring data documenting violations of the 24-hour $PM_{2.5}$ standard. Communities that will have this perspective include Chena Ridge, Ester, Ester Valley, Fox, Goldstream Valley, and North Pole. Despite the lack of monitoring data, insight gained from the review of the nine-factors (particularly, the combination of population density, emissions sources, meteorology and terrain) indicates that it would be prudent to include these areas within the proposed nonattainment area. The recommended nonattainment area is therefore considered to be conservative and protective of public health.

Figure 17
Combined FMATS and Proposed PM_{10} Nonattainment Boundary

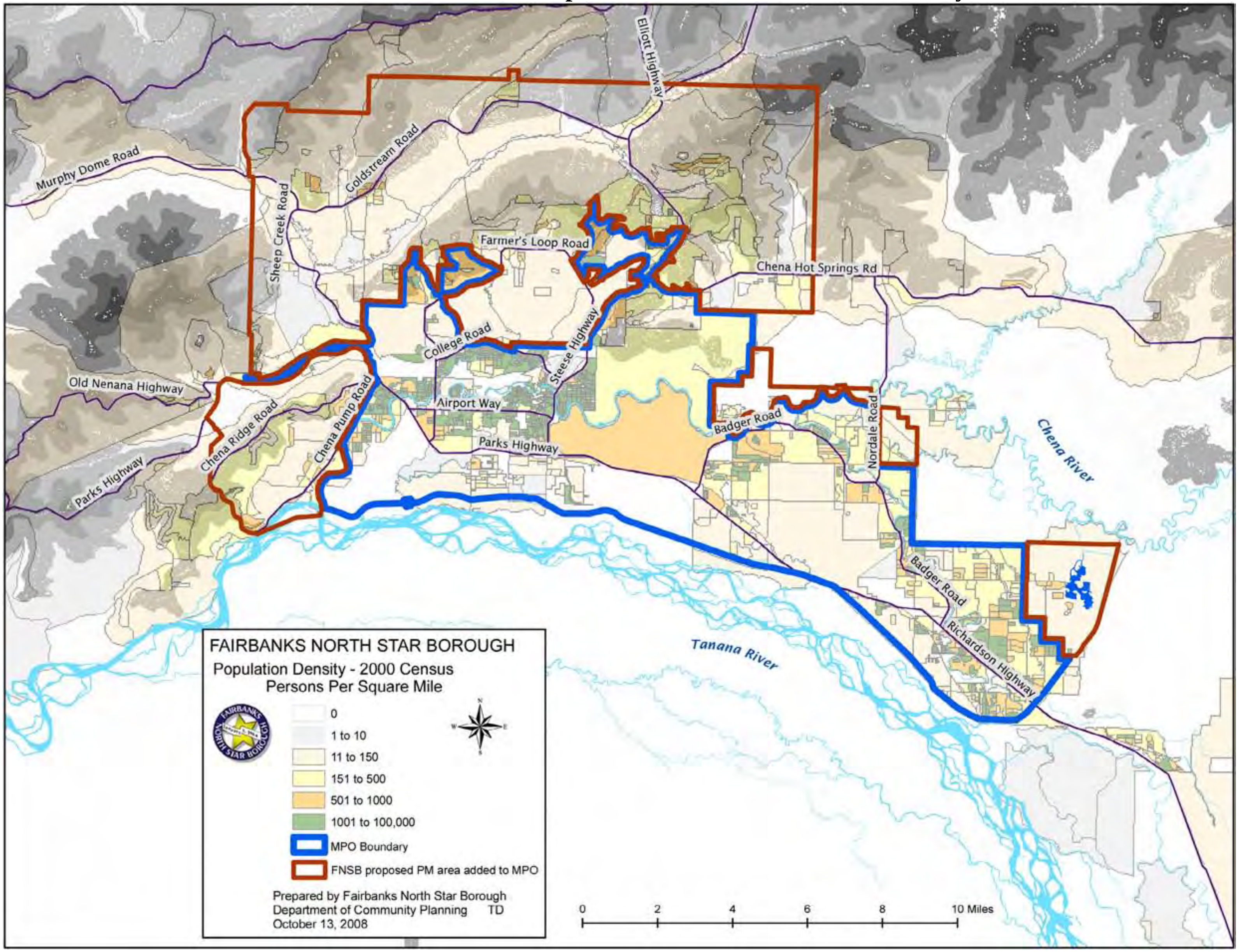
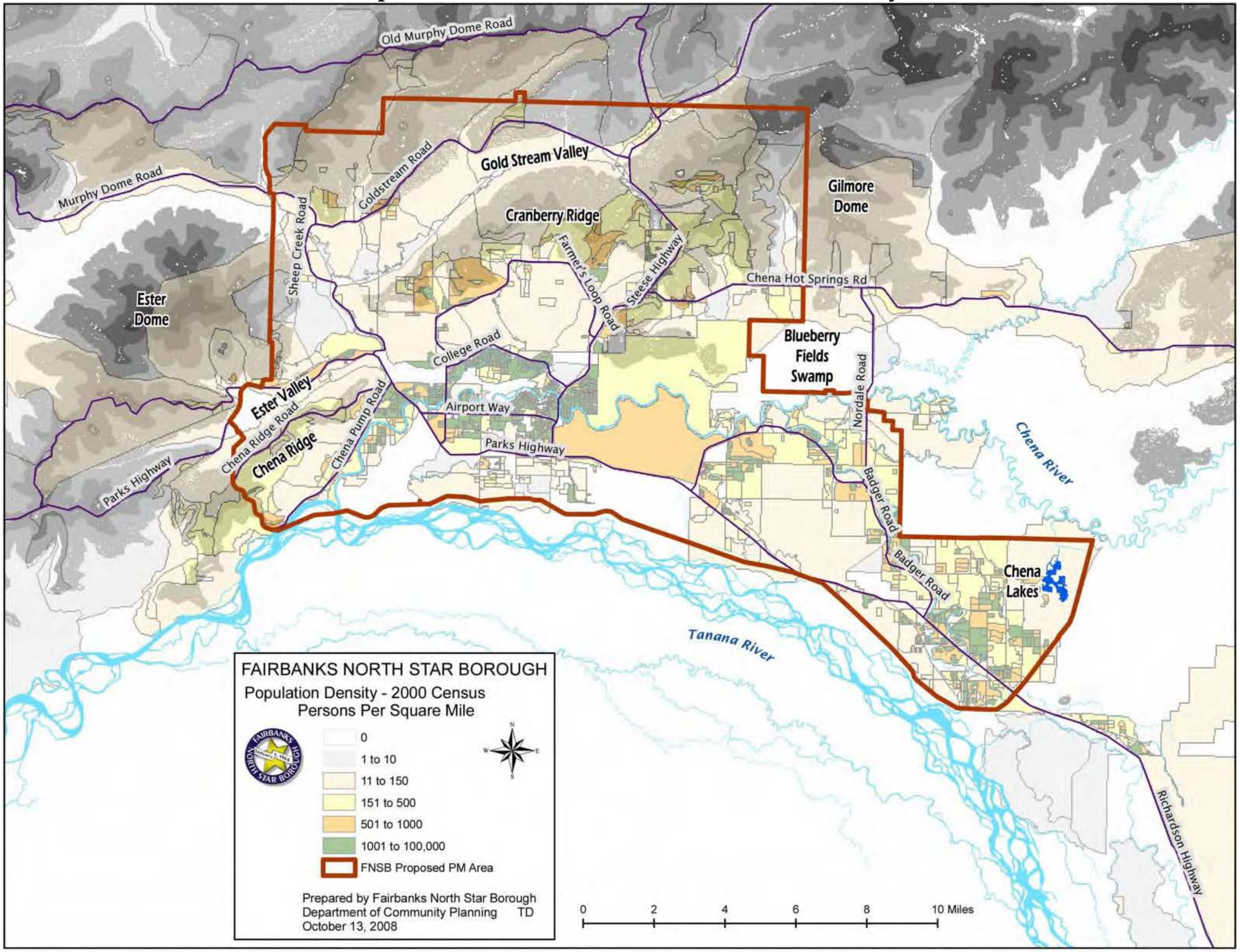


Figure 18
Proposed Fairbanks $PM_{2.5}$ Nonattainment Boundary



Attachment A

Emission Category	Fairbanks North Star Borough						
	2005 Emissions, TPY						
	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
Point	67	5829	4565	460	NA	NA	1087
Area	4473	1872	1055	7523	6444	337	76433
Mobile - Onroad	1160	2218	161	71	56	55	14510
Mobile - Nonroad	1241	543	34	19245	3398	0	6144
Total Emissions	**6941**	**10462**	**5815**	**27299**	**9898**	**392**	**98174**

Fairbanks North Star Borough					
Facility	2005 Emissions (TPY)				
	VOC	NOx	SO_2	PM_{10}_PRI	CO
Aurora Energy LLC Chena Power Plant	0	629	248	353	459
Flint Hills Resources Alaska, LLC North Pole Refinery	35	215	13	15	33
Golden Valley Electric Association North Pole Power Plant	2	3604	3019	50	14
Golden Valley Electric Association Zehnder Facility	1	28	24	0	1
US Air Force Eielson Air Force Base	21	367	281	8	125
US Army Fort Wainwright	6	471	697	14	262
University of Alaska Fairbanks Campus Power Plant	2	509	280	7	187
Wilder Construction Company Asphalt Plant	0	6	3	13	6
Total Emissions	67	5829	4565	460	1087

Fairbanks North Star Borough - Area Sources							
	2005 Emissions, TPY						
Source Classification Code	**VOC**	**NOx**	**SO_2**	**PM_{10}_PRI**	**$PM_{2.5}$_PRI**	**NH_3**	**CO**
2103006000 Stationary Source Fuel Combustion Commercial/Institutional Natural Gas Total: Boilers and IC Engines	0	0	0	0	0	0	0
2104004000 Stationary Source Fuel Combustion Residential Distillate Oil Total: All Combustor Types	9	229	605	5	5	0	64
2104005000 Stationary Source Fuel Combustion Residential Residual Oil Total: All Combustor Types	0	2	5	0	0	0	1
2104006010 Stationary Source Fuel Combustion Residential Natural Gas Residential Furnaces	0	7	0	0	0	0	2
2104007000 Stationary Source Fuel Combustion Residential Liquified Petroleum Gas (LPG) Total: All Combustor Types	0	4	0	0	0	0	1
2104008000 Stationary Source Fuel Combustion Residential Wood Total: Woodstoves and Fireplaces	509	19	3	183	183	0	1325
2306010000 Industrial Processes Petroleum Refining: SIC 29 Asphalt Paving/Roofing Materials Total	0	1	1	40	2	0	4
2401001000 Solvent Utilization Surface Coating Architectural Coatings Total: All Solvent Types	241	0	0	0	0	0	0
2461020000 Solvent Utilization Miscellaneous Non-industrial: Commercial Asphalt Application: All Processes Total: All Solvent Types	1	0	0	0	0	0	0
2501000120 Storage and Transport Petroleum and Petroleum Product Storage All Storage Types: Breathing Loss Gasoline	15	0	0	0	0	0	0
2501060102 Storage and Transport Petroleum and Petroleum Product Storage Gasoline Service Stations Stage 2: Displacement Loss/Controlled	150	0	0	0	0	0	0
2501060103 Storage and Transport Petroleum and Petroleum Product Storage Gasoline Service Stations Stage 2: Spillage	8	0	0	0	0	0	0
2501995120 Storage and Transport Petroleum and Petroleum Product Storage All Storage Types: Working Loss Gasoline	8	0	0	0	0	0	0
2810001000 Miscellaneous Area Sources Other Combustion Forest Wildfires Total	3529	1609	441	7292	6254	337	74997
2810030000 Miscellaneous Area Sources Other Combustion Structure Fires Total	3	1	0	3	0	0	39
2810035000 Miscellaneous Area Sources Other Combustion Firefighting Training Total	0	0	0	0	0	0	0
Total Area Source Emissions	4473	1872	1055	7523	6444	337	76433

Fairbanks North Star Borough - OnRoad Mobile Sources							
	2005 Emissions, TPY						
Source Classification Code	**VOC**	**NOx**	**SO_2**	**PM_{10}_PRI**	**$PM_{2.5}$_PRI**	**NH_3**	**CO**
2201001000 Mobile Sources Highway Vehicles - Gasoline Light Duty Gasoline Vehicles (LDGV) Total: All Road Types	308	173	7	5	2	18	4101
2201020000 Mobile Sources Highway Vehicles - Gasoline Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5) Total: All Road Types	396	236	9	6	3	19	5658
2201040000 Mobile Sources Highway Vehicles - Gasoline Light Duty Gasoline Trucks 3 & 4 (M6) = LDGT2 (M5) Total: All Road Types	304	194	8	4	2	13	3711
2201070000 Mobile Sources Highway Vehicles - Gasoline Heavy Duty Gasoline Vehicles 2B thru 8B & Buses (HDGV) Total: All Road Types	91	240	5	5	4	2	717
2201080000 Mobile Sources Highway Vehicles - Gasoline Motorcycles (MC) Total: All Road Types	7	5	0	0	0	0	39
2230001000 Mobile Sources Highway Vehicles - Diesel Light Duty Diesel Vehicles (LDDV) Total: All Road Types	0	1	0	0	0	0	1
2230060000 Mobile Sources Highway Vehicles - Diesel Light Duty Diesel Trucks 1 thru 4 (M6) (LDDT) Total: All Road Types	2	3	1	0	0	0	3
2230070000 Mobile Sources Highway Vehicles - Diesel All HDDV including Buses (use subdivisions -071 thru -075 if possible) Total: All Road Types	52	1366	131	51	45	3	280
Total On-Road Emissions	1160	2218	161	71	56	55	14510

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
2260001010 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Recreational Equipment Motorcycles: Off-road	40	0	0	1	1	0	55
2260001020 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Recreational Equipment Snowmobiles	829	6	0	18	17	0	2021
2260001030 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Recreational Equipment All Terrain Vehicles	25	0	0	1	1	0	84
2260001060 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Recreational Equipment Specialty Vehicles/Carts	0	0	0	0	0	0	4
2260002006 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Tampers/Rammers	1	0	0	0	0	0	4
2260002009 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Plate Compactors	0	0	0	0	0	0	0
2260002021 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Paving Equipment	0	0	0	0	0	0	0
2260002027 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Signal Boards/Light Plants	0	0	0	0	0	0	0
2260002039 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Concrete/Industrial Saws	2	0	0	0	0	0	12
2260002054 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Construction and Mining Equipment Crushing/Processing Equipment	0	0	0	0	0	0	0
2260003030 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Industrial Equipment Sweepers/Scrubbers	0	0	0	0	0	0	0
2260003040 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Industrial Equipment Other General Industrial Equipment	0	0	0	0	0	0	0
2260004015 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Rotary Tillers < 6 HP (Residential)	0	0	0	0	0	0	1
2260004016 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Rotary Tillers < 6 HP (Commercial)	0	0	0	0	0	0	0
2260004020 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Chain Saws < 6 HP (Residential)	1	0	0	0	0	0	5
2260004021 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Chain Saws < 6 HP (Commercial)	0	0	0	0	0	0	1
2260004025 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Trimmers/Edgers/Brush Cutters (Residential)	2	0	0	0	0	0	12
2260004026 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Trimmers/Edgers/Brush Cutters (Commercial)	0	0	0	0	0	0	1
2260004030 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Leafblowers/Vacuums (Residential)	2	0	0	0	0	0	8
2260004031 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Leafblowers/Vacuums (Commercial)	0	0	0	0	0	0	1
2260004035 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Snowblowers (Residential)	0	0	0	0	0	0	0
2260004036 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Snowblowers (Commercial)	0	0	0	0	0	0	0
2260004071 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Lawn and Garden Equipment Turf Equipment (Commercial)	0	0	0	0	0	0	0
2260005035 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Agricultural Equipment Sprayers	0	0	0	0	0	0	0
2260006005 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Commercial Equipment Generator Sets	0	0	0	0	0	0	1
2260006010 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Commercial Equipment Pumps	1	0	0	0	0	0	4
2260006015 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Commercial Equipment Air Compressors	0	0	0	0	0	0	0
2260006035 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Mobile Sources : Off-highway Vehicle Gasoline, 2-Stroke: Commercial Equipment Mobile Sources : Off-highway Vehicle Gasoline, 2-Stroke: Commercial Equipment : Hydro-power Units	0	0	0	0	0	0	0
2260007005 Mobile Sources Off-highway Vehicle Gasoline, 2-Stroke Logging Equipment Chain Saws > 6 HP	1	0	0	0	0	0	6
2265001010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Recreational Equipment Motorcycles: Off-road	2	0	0	0	0	0	20
2265001030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Recreational Equipment All Terrain Vehicles	21	2	0	0	0	0	267

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
2265001050 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Recreational Equipment Golf Carts	2	1	0	0	0	0	141
2265001060 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Recreational Equipment Specialty Vehicles/Carts	0	0	0	0	0	0	3
2265002003 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Pavers	0	0	0	0	0	0	5
2265002006 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Tampers/Rammers	0	0	0	0	0	0	0
2265002009 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Plate Compactors	0	0	0	0	0	0	9
2265002015 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Rollers	0	0	0	0	0	0	9
2265002021 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Paving Equipment	0	0	0	0	0	0	18
2265002024 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Surfacing Equipment	0	0	0	0	0	0	8
2265002027 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Signal Boards/Light Plants	0	0	0	0	0	0	0
2265002030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Trenchers	0	0	0	0	0	0	14
2265002033 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Bore/Drill Rigs	0	0	0	0	0	0	4
2265002039 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Concrete/Industrial Saws	0	0	0	0	0	0	37
2265002042 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Cement and Mortar Mixers	0	0	0	0	0	0	16
2265002045 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Cranes	0	0	0	0	0	0	0
2265002054 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Crushing/Processing Equipment	0	0	0	0	0	0	2
2265002057 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Rough Terrain Forklifts	0	0	0	0	0	0	0
2265002060 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Rubber Tire Loaders	0	0	0	0	0	0	0
2265002066 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Tractors/Loaders/Backhoes	0	0	0	0	0	0	12
2265002072 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Skid Steer Loaders	0	0	0	0	0	0	4
2265002078 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Dumpers/Tenders	0	0	0	0	0	0	2
2265002081 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Construction and Mining Equipment Other Construction Equipment	0	0	0	0	0	0	0
2265003010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Aerial Lifts	0	0	0	0	0	0	1
2265003020 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Forklifts	0	0	0	0	0	0	2
2265003030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Sweepers/Scrubbers	0	0	0	0	0	0	1
2265003040 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Other General Industrial Equipment	0	0	0	0	0	0	3
2265003050 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Other Material Handling Equipment	0	0	0	0	0	0	0
2265003060 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment AC\Refrigeration	0	0	0	0	0	0	0
2265003070 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Terminal Tractors	0	0	0	0	0	0	0
2265004010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Lawn Mowers (Residential)	7	1	0	0	0	0	222
2265004011 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Lawn Mowers (Commercial)	0	0	0	0	0	0	6
2265004015 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Rotary Tillers < 6 HP (Residential)	1	0	0	0	0	0	19
2265004016 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Rotary Tillers < 6 HP (Commercial)	0	0	0	0	0	0	3
2265004025 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Trimmers/Edgers/Brush Cutters (Residential)	0	0	0	0	0	0	1
2265004026 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Trimmers/Edgers/Brush Cutters (Commercial)	0	0	0	0	0	0	0

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
2265004030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Leafblowers/Vacuums (Residential)	0	0	0	0	0	0	2
2265004031 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Leafblowers/Vacuums (Commercial)	0	0	0	0	0	0	6
2265004035 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Snowblowers (Residential)	0	0	0	0	0	0	0
2265004036 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Snowblowers (Commercial)	0	0	0	0	0	0	0
2265004040 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Rear Engine Riding Mowers (Residential)	1	0	0	0	0	0	57
2265004041 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Rear Engine Riding Mowers (Commercial)	0	0	0	0	0	0	1
2265004046 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Front Mowers (Commercial)	0	0	0	0	0	0	1
2265004051 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Shredders < 6 HP (Commercial)	0	0	0	0	0	0	0
2265004055 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Lawn and Garden Tractors (Residential)	12	4	0	0	0	0	764
2265004056 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Lawn and Garden Tractors (Commercial)	0	0	0	0	0	0	11
2265004066 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Chippers/Stump Grinders (Commercial)	0	0	0	0	0	0	1
2265004071 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Turf Equipment (Commercial)	0	0	0	0	0	0	33
2265004075 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Other Lawn and Garden Equipment (Residential)	1	0	0	0	0	0	23
2265004076 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Lawn and Garden Equipment Other Lawn and Garden Equipment (Commercial)	0	0	0	0	0	0	1
2265005010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment 2-Wheel Tractors	0	0	0	0	0	0	0
2265005015 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Agricultural Tractors	0	0	0	0	0	0	0
2265005020 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Combines	0	0	0	0	0	0	0
2265005025 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Balers	0	0	0	0	0	0	0
2265005030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Agricultural Mowers	0	0	0	0	0	0	0
2265005035 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Sprayers	0	0	0	0	0	0	2
2265005040 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Tillers > 6 HP	0	0	0	0	0	0	6
2265005045 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Swathers	0	0	0	0	0	0	0
2265005055 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Other Agricultural Equipment	0	0	0	0	0	0	1
2265005060 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Agricultural Equipment Irrigation Sets	0	0	0	0	0	0	0
2265006005 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Commercial Equipment Generator Sets	6	1	0	0	0	0	297
2265006010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Commercial Equipment Pumps	1	0	0	0	0	0	65
2265006015 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Commercial Equipment Air Compressors	1	1	0	0	0	0	52
2265006025 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Commercial Equipment Welders	1	0	0	0	0	0	82
2265006030 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Commercial Equipment Pressure Washers	3	1	0	0	0	0	129
2265006035 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Mobile Sources : Off-highway Vehicle Gasoline, 4-Stroke: Commercial Equipment Mobile Sources : Off-highway Vehicle Gasoline, 4-Stroke: Commercial Equipment : Hydro-power Units	0	0	0	0	0	0	7
2265007010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Logging Equipment Shredders > 6 HP	0	0	0	0	0	0	18
2265007015 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Logging Equipment Forest Eqp - Feller/Bunch/Skidder	0	0	0	0	0	0	0

Fairbanks North Star Borough - NonRoad Mobile Emissions							
Source Classification Code	2005 Emissions, TPY						
	VOC	NOx	SO_2	PM_{10}_PRI	$PM_{2.5}$_PRI	NH_3	CO
2265010010 Mobile Sources Off-highway Vehicle Gasoline, 4-Stroke Industrial Equipment Other Oil Field Equipment	0	0	0	0	0	0	27
2267001060 Mobile Sources LPG Recreational Equipment Specialty Vehicles/Carts	0	0	0	0	0	0	0
2267002003 Mobile Sources LPG Construction and Mining Equipment Pavers	0	0	0	0	0	0	0
2267002015 Mobile Sources LPG Construction and Mining Equipment Rollers	0	0	0	0	0	0	0
2267002021 Mobile Sources LPG Construction and Mining Equipment Paving Equipment	0	0	0	0	0	0	0
2267002024 Mobile Sources LPG Construction and Mining Equipment Surfacing Equipment	0	0	0	0	0	0	0
2267002030 Mobile Sources LPG Construction and Mining Equipment Trenchers	0	0	0	0	0	0	0
2267002033 Mobile Sources LPG Construction and Mining Equipment Bore/Drill Rigs	0	0	0	0	0	0	0
2267002039 Mobile Sources LPG Construction and Mining Equipment Concrete/Industrial Saws	0	0	0	0	0	0	0
2267002045 Mobile Sources LPG Construction and Mining Equipment Cranes	0	0	0	0	0	0	0
2267002054 Mobile Sources LPG Construction and Mining Equipment Crushing/Processing Equipment	0	0	0	0	0	0	0
2267002057 Mobile Sources LPG Construction and Mining Equipment Rough Terrain Forklifts	0	0	0	0	0	0	0
2267002060 Mobile Sources LPG Construction and Mining Equipment Rubber Tire Loaders	0	0	0	0	0	0	0
2267002066 Mobile Sources LPG Construction and Mining Equipment Tractors/Loaders/Backhoes	0	0	0	0	0	0	0
2267002072 Mobile Sources LPG Construction and Mining Equipment Skid Steer Loaders	0	0	0	0	0	0	0
2267002081 Mobile Sources LPG Construction and Mining Equipment Other Construction Equipment	0	0	0	0	0	0	0
2267003010 Mobile Sources LPG Industrial Equipment Aerial Lifts	0	0	0	0	0	0	0
2267003020 Mobile Sources LPG Industrial Equipment Forklifts	1	5	0	0	0	0	24
2267003030 Mobile Sources LPG Industrial Equipment Sweepers/Scrubbers	0	0	0	0	0	0	0
2267003040 Mobile Sources LPG Industrial Equipment Other General Industrial Equipment	0	0	0	0	0	0	0
2267003050 Mobile Sources LPG Industrial Equipment Other Material Handling Equipment	0	0	0	0	0	0	0
2267003070 Mobile Sources LPG Industrial Equipment Terminal Tractors	0	0	0	0	0	0	0
2267004066 Mobile Sources LPG Lawn and Garden Equipment Chippers/Stump Grinders (Commercial)	0	0	0	0	0	0	0
2267005055 Mobile Sources LPG Agricultural Equipment Other Agricultural Equipment	0	0	0	0	0	0	0
2267005060 Mobile Sources LPG Agricultural Equipment Irrigation Sets	0	0	0	0	0	0	0
2267006005 Mobile Sources LPG Commercial Equipment Generator Sets	0	0	0	0	0	0	2
2267006010 Mobile Sources LPG Commercial Equipment Pumps	0	0	0	0	0	0	0
2267006015 Mobile Sources LPG Commercial Equipment Air Compressors	0	0	0	0	0	0	1
2267006025 Mobile Sources LPG Commercial Equipment Welders	0	0	0	0	0	0	0
2267006030 Mobile Sources LPG Commercial Equipment Pressure Washers	0	0	0	0	0	0	0
2267006035 Mobile Sources LPG Mobile Sources : LPG: Commercial Equipment Mobile Sources : LPG: Commercial Equipment : Hydro-power Units	0	0	0	0	0	0	0
2268002081 Mobile Sources CNG Construction and Mining Equipment Other Construction Equipment	0	0	0	0	0	0	0
2268003020 Mobile Sources CNG Industrial Equipment Forklifts	0	0	0	0	0	0	2
2268003030 Mobile Sources CNG Industrial Equipment Sweepers/Scrubbers	0	0	0	0	0	0	0

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	**VOC**	**NOx**	**SO_2**	**PM_{10}_PRI**	**$PM_{2.5}$_PRI**	**NH_3**	**CO**
2268003040 Mobile Sources CNG Industrial Equipment Other General Industrial Equipment	0	0	0	0	0	0	0
2268003060 Mobile Sources CNG Industrial Equipment AC\Refrigeration	0	0	0	0	0	0	0
2268003070 Mobile Sources CNG Industrial Equipment Terminal Tractors	0	0	0	0	0	0	0
2268005055 Mobile Sources CNG Agricultural Equipment Other Agricultural Equipment	0	0	0	0	0	0	0
2268005060 Mobile Sources CNG Agricultural Equipment Irrigation Sets	0	0	0	0	0	0	0
2268006005 Mobile Sources CNG Commercial Equipment Generator Sets	0	0	0	0	0	0	1
2268006010 Mobile Sources CNG Commercial Equipment Pumps	0	0	0	0	0	0	0
2268006015 Mobile Sources CNG Commercial Equipment Air Compressors	0	0	0	0	0	0	0
2268006020 Mobile Sources CNG Commercial Equipment Gas Compressors	0	0	0	0	0	0	3
2268006035 Mobile Sources CNG Mobile Sources : CNG: Commercial Equipment Mobile Sources : CNG: Commercial Equipment : Hydro-power Units	0	0	0	0	0	0	0
2268010010 Mobile Sources CNG Industrial Equipment Other Oil Field Equipment	0	0	0	0	0	0	0
2270001060 Mobile Sources Off-highway Vehicle Diesel Recreational Equipment Specialty Vehicles/Carts	0	0	0	0	0	0	0
2270002003 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Pavers	0	1	0	0	0	0	0
2270002006 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Tampers/Rammers	0	0	0	0	0	0	0
2270002009 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Plate Compactors	0	0	0	0	0	0	0
2270002015 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Rollers	0	2	0	0	0	0	1
2270002018 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Scrapers	0	2	0	0	0	0	1
2270002021 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Paving Equipment	0	0	0	0	0	0	0
2270002024 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Surfacing Equipment	0	0	0	0	0	0	0
2270002027 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Signal Boards/Light Plants	0	1	0	0	0	0	0
2270002030 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Trenchers	0	2	0	0	0	0	1
2270002033 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Bore/Drill Rigs	0	2	0	0	0	0	1
2270002036 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Excavators	1	6	0	0	0	0	2
2270002039 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Concrete/Industrial Saws	0	0	0	0	0	0	0
2270002042 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Cement and Mortar Mixers	0	0	0	0	0	0	0
2270002045 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Cranes	0	2	0	0	0	0	1
2270002048 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Graders	0	1	0	0	0	0	1
2270002051 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Off-highway Trucks	1	8	0	0	0	0	1
2270002054 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Crushing/Processing Equipment	0	0	0	0	0	0	0
2270002057 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Rough Terrain Forklifts	0	3	0	0	0	0	2
2270002060 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Rubber Tire Loaders	1	11	0	1	1	0	4
2270002066 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Tractors/Loaders/Backhoes	2	10	0	1	1	0	9
2270002069 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Crawler Tractor/Dozers	1	8	0	0	0	0	3
2270002072 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Skid Steer Loaders	2	8	0	1	1	0	8

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	**VOC**	**NOx**	**SO_2**	**PM_{10}_PRI**	**$PM_{2.5}$_PRI**	**NH_3**	**CO**
2270002075 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Off-highway Tractors	0	1	0	0	0	0	0
2270002078 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Dumpers/Tenders	0	0	0	0	0	0	0
2270002081 Mobile Sources Off-highway Vehicle Diesel Construction and Mining Equipment Other Construction Equipment	0	1	0	0	0	0	1
2270003010 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Aerial Lifts	0	0	0	0	0	0	0
2270003020 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Forklifts	0	1	0	0	0	0	0
2270003030 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Sweepers/Scrubbers	0	0	0	0	0	0	0
2270003040 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Other General Industrial Equipment	0	0	0	0	0	0	0
2270003050 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Other Material Handling Equipment	0	0	0	0	0	0	0
2270003060 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment AC\Refrigeration	0	5	0	0	0	0	2
2270003070 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Terminal Tractors	0	0	0	0	0	0	0
2270004031 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Leafblowers/Vacuums (Commercial)	0	0	0	0	0	0	0
2270004036 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Snowblowers (Commercial)	0	0	0	0	0	0	0
2270004046 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Front Mowers (Commercial)	0	0	0	0	0	0	0
2270004056 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Lawn and Garden Tractors (Commercial)	0	0	0	0	0	0	0
2270004066 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Chippers/Stump Grinders (Commercial)	0	0	0	0	0	0	0
2270004071 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Turf Equipment (Commercial)	0	0	0	0	0	0	0
2270004076 Mobile Sources Off-highway Vehicle Diesel Lawn and Garden Equipment Other Lawn and Garden Equipment (Commercial)	0	0	0	0	0	0	0
2270005010 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment 2-Wheel Tractors	0	0	0	0	0	0	0
2270005015 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Agricultural Tractors	1	10	0	1	1	0	4
2270005020 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Combines	0	1	0	0	0	0	0
2270005025 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Balers	0	0	0	0	0	0	0
2270005030 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Agricultural Mowers	0	0	0	0	0	0	0
2270005035 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Sprayers	0	0	0	0	0	0	0
2270005040 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Tillers > 6 HP	0	0	0	0	0	0	0
2270005045 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Swathers	0	0	0	0	0	0	0
2270005055 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Other Agricultural Equipment	0	0	0	0	0	0	0
2270005060 Mobile Sources Off-highway Vehicle Diesel Agricultural Equipment Irrigation Sets	0	0	0	0	0	0	0
2270006005 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Generator Sets	0	3	0	0	0	0	1
2270006010 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Pumps	0	1	0	0	0	0	0
2270006015 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Air Compressors	0	3	0	0	0	0	1
2270006020 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Gas Compressors	0	0	0	0	0	0	0
2270006025 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Welders	0	1	0	0	0	0	1
2270006030 Mobile Sources Off-highway Vehicle Diesel Commercial Equipment Pressure Washers	0	0	0	0	0	0	0
2270006035 Mobile Sources Off-highway Vehicle Diesel Mobile Sources : Off-highway Vehicle Diesel: Commercial Equipment Mobile Sources : Off-highway Vehicle Diesel: Commercial Equipment : Hydro-power Units	0	0	0	0	0	0	0

Fairbanks North Star Borough - NonRoad Mobile Emissions							
	2005 Emissions, TPY						
Source Classification Code	**VOC**	**NOx**	**SO_2**	**PM_{10}_PRI**	**$PM_{2.5}$_PRI**	**NH_3**	**CO**
2270007010 Mobile Sources Off-highway Vehicle Diesel Logging Equipment Shredders > 6 HP	0	0	0	0	0	0	0
2270007015 Mobile Sources Off-highway Vehicle Diesel Logging Equipment Forest Eqp - Feller/Bunch/Skidder	0	1	0	0	0	0	0
2270009010 Mobile Sources Off-highway Vehicle Diesel Underground Mining Equipment Other Underground Mining Equipment	0	0	0	0	0	0	0
2270010010 Mobile Sources Off-highway Vehicle Diesel Industrial Equipment Other Oil Field Equipment	0	1	0	0	0	0	0
2280002030 Mobile Sources Marine Vessels, Commercial Diesel Fishing Vessels	0	2	1	0	0	0	0
2280004030 Mobile Sources Marine Vessels, Commercial Gasoline Fishing Vessels	0	0	0	0	0	0	4
2282005010 Mobile Sources Pleasure Craft Gasoline 2-Stroke Outboard	4	0	0	0	0	0	13
2282005015 Mobile Sources Pleasure Craft Gasoline 2-Stroke Personal Water Craft	1	0	0	0	0	0	5
2282010005 Mobile Sources Pleasure Craft Gasoline 4-Stroke Inboard/Sterndrive	1	1	0	0	0	0	8
2282020005 Mobile Sources Pleasure Craft Diesel Inboard/Sterndrive	0	1	0	0	0	0	0
2282020010 Mobile Sources Pleasure Craft Diesel Outboard	0	0	0	0	0	0	0
2285002015 Mobile Sources Railroad Equipment Diesel Railway Maintenance	0	1	0	0	0	0	1
2285004015 Mobile Sources Railroad Equipment Gasoline, 4-Stroke Railway Maintenance	0	0	0	0	0	0	2
2285006015 Mobile Sources Railroad Equipment LPG Railway Maintenance	0	0	0	0	0	0	0
2294000000 Mobile Sources Paved Roads All Paved Roads Total: Fugitives	0	0	0	5507	1312	0	0
2296000000 Mobile Sources Unpaved Roads All Unpaved Roads Total: Fugitives	0	0	0	13626	2042	0	0
2275001000	202	155	18	61		0	329
2275020000	33	82	7	16	16	0	405
2275050000	17	5	1	7		0	642
2275060000	0	0	0	0	0	0	0
2285002000	9	179	7	5	5	0	22
Total NonRoad Emissions	1241	543	34	19245	3398	0	6144

Attachment B

	By:	Karl Kassel
	Introduced:	03/26/2015
	Adopted:	03/26/2015

FAIRBANKS NORTH STAR BOROUGH

RESOLUTION NO. 2015 – 12

A RESOLUTION TO CONFIRM THE EXACT BOUNDARIES OF THE AIR QUALITY CONTROL ZONE SET FORTH IN ORDINANCE NO. 2015-01 AND ADOPTED ON FEBRUARY 27, 2015

WHEREAS, On February 27, 2015 the Fairbanks North Star Borough Assembly adopted Ordinance No. 2015-01 relating to Air Quality; and

WHEREAS, Within Ordinance No. 2015-01, an Air Quality Control Zone was created using the EPA's non-attainment area's southern, western, and eastern boundaries, and defining a new northern boundary; and

WHEREAS, the new northern boundary used geographic landmarks such as "Farmers Loop Ridge" and "ridge crest across Nottingham Drive" that bisect individual lots; and

WHEREAS, it is undesirable to have a portion of a lot contained within the Air Quality Control Zone; and

WHEREAS, FNSB Staff administratively completed the northern boundary of the Air Quality Control Zone using public right-of-way, subdivision boundaries, and individual lot boundaries, while following the intended geographic features as closely as possible; and

WHEREAS, It is necessary to confirm the exact northern boundary of the Air Quality Control Zone;

NOW THEREFORE BE IT RESOLVED, That the boundary description (Attachment A) and map (Attachment B) accurately reflect the adopted Air Quality Control Zone in Ordinance No. 2015-01.

PASSED AND APPROVED THIS 26TH DAY OF MARCH, 2015.

Karl Kassel
Presiding Officer

ATTEST:

Nanci Ashford-Bingham, MMC
Borough Clerk

Ayes: Golub, Sattley, Hutchison, Lawrence, Dodge, Quist, Davies, Kassel
Noes: None
Excused: Roberts

ATTACHMENT "A"

RESOLUTION NO. 2015- 12

"Air Quality Control Zone" means the area of the Borough currently contained in the EPA designated non-attainment area, which uses the *non-attainment area's southern, western and eastern boundaries* as modified by their respective intersection with the following *northern boundary* as described:

– Beginning at the intersection of the western boundary of Section 20, T1S, R2W, FM and Isberg Road on the *western boundary of the EPA designated non-attainment area*
– Continuing easterly on Isberg Road to Chena Ridge Road
– Then northeasterly on Chena Ridge Road to Chena Pump Road
– Continuing northeasterly on Chena Pump Road to the Parks Highway
– Then northerly on the Parks Highway to Sheep Creek Road
– Continuing northerly on Sheep Creek Road to the western boundary of Section 36, T1N, R2W, FM
– Then northerly along the western boundary of Section 36 to the southern boundary of Section 25, T1N, R2W, FM
– Then easterly along the southern boundary of Section 25 to the SW corner of the Maggofin Highlands Subdivision *{{FRD Plat No. 2008-016, rec. 3/12/2008}}*
– Then northerly along the western boundary of the Maggofin Highlands Subdivision to the SW corner of TL-2539, Section 25, T1N, R2W, FM *{{FRD Inst. No. 2011-021111-0, rec. 10/26/2011}}*
– Continuing northerly along its western boundary to its NW corner
– Then easterly along its northern boundary to a point on the western boundary of TL-2509, Section 25, T1N, R2W, FM *{{FRD Inst. No. 2008-016977-0, rec. 08/21/2008}}*
– Then northerly along western boundary of TL-2509 to its NW corner
– Then easterly along its northern boundary to the NW corner of TL-2504, Section 25, T1N, R2W, FM *{{FRD Book 1136, Page 891, rec. 4/28/1999}}*
– Continuing easterly along the northern boundary of TL-2504 to the NW corner of TL-2512, Section 25, T1N, R2W, FM *{{FRD Book 01201, Page 0792, rec. 6/12/2000}}*
– Continuing easterly along the northern boundary of TL-2512 to the SW corner of TL-2518, Section 25, T1N, R2W, FM *{{FRD Book 117, Page 792, rec. 8/5/1978}}*

– Then northerly along the western boundary of TL-2518 to its NW corner

– Then easterly along its northern boundary to the SW corner of TL-2547, Section 25, T1N, R2W, FM *{{FRD Inst. No. 2014-012678-0, rec. 9/5/2014}}*

– Then northerly along the western boundary of TL-2547 to its NW corner

– Then easterly along its northern boundary to the NW corner of TL-2546, Section 25, T1N, R2W, FM *{{FRD Inst. No. 2005-021943-0, rec. 10/11/2005}}*

– Continuing easterly along the northern boundary of TL-2546 to the SW corner of TL-2527, Section 25, T1N, R2W, FM *{{FRD Book 258, Page 293, rec. 6/7/1971}}*

– Then northerly along the western boundary of TL-2527 to its NW corner

– Then easterly along its northern boundary to the NW corner of TL-2528, Section 25, T1N, R2W, FM *{{FRD Inst. No. 2002-025194-0, rec 12/12/2002}}*

– Continuing easterly along the northern boundary of TL-2528 to its NE corner

– Then northeasterly across Dalton Trail to the NW corner of Lot 24 of the College Hills Estates Subdivision *{{FRD Plat No. 1981-111, rec. 7/22/1981}}* where Dalton Trail meets Goldfinch Road

– Then following Goldfinch Road to the northern most corner of Lot 25 of the College Hills Estates Subdivision where Goldfinch Trail meets Kingfisher Drive

– Then across Kingfisher Drive to the west corner of Lot 56 of the College Hills Estates Subdivision, 1st Addition *{{FRD Plat No. 1981-135, rec. 9/4/1981}}*

– Continuing on Goldfinch Road to the NE corner of Lot 69 of the College Hills Estates Subdivision, 1st Addition where Goldfinch Road meets Ballaine Road

– Then across Ballaine Road to the NW corner of Tract B of the Pearl Creek Subdivision *{{FRD Plat No. 1984-199, rec. 9/5/1984}}*

– Then northerly on Ballaine Road to the corner of Lot 1, Block 2 of the Musk Ox Subdivision *{{FRD Plat No. 63-8456, rec 12/4/1963}}* where Red Fox Drive meets Eldorado Road

– Then northeasterly on Eldorado Road to the corner of Lot 6, Block 2 of the Musk Ox Subdivision where Eldorado Road Moose Trail

– Then easterly on Moose Trail to NW corner of Lot 1, Block 7 of the Musk Ox Subdivision, 1st Addition *{{FRD Plat No. 1964-7557, rec. 10/20/1964}}*

– Continuing easterly along the northern boundary of Lot 1 to a point on the western boundary of Lot 1 of the Aspen Grove Subdivision *{{FRD Plat No. 1971-9495, rec 9/2/1971}}*

– Then northerly along the western boundary of Lot 1 of the Aspen Grove Subdivision to its NW corner, which is a point on the northern boundary of Section 20, T1N, R1W, FM

- Then easterly along the northern boundary of Section 20 to the SW Section corner of Section 16, T1N, R1W, FM
- Then northerly along the western boundary of Section 16 to the SW corner of TL-1602, Section 16, T1N, R1W, FM *{{FRD Book 655, Page 0997, rec. 3/7/1990}}*
- Then easterly along the southern boundary of TL-1602 to its SE corner
- Then northerly along its eastern boundary to its NE corner, which is common to the southern boundary of Tract A *{{ FRD Inst. No. 2011-017496-0, rec. 9/14/2011 }}*
- Then easterly along the southern boundary of Tract A to a point on the western boundary of Section 15, T1N, 1W, FM
- Then northerly along the western boundary of Section 15 to Noel Drive within Ridgetop Subdivision, 2nd Addition *{{FRD Plat No. 1978-142, rec. 9/13/1978}}*
- Then easterly on Noel Drive to the SE corner Lot 1, Block 1 of the Ridgetop Subdivision, 1st Addition *{{FRD Plat No. 1978-099, rec. 6/9/1978}}* where Noel Drive meets Cranberry Ridge Road
- Continuing easterly on Cranberry Ridge Drive (formally Eaton Drive) along Ridgetop Subdivision *{{FRD Plat No. 1977-226, rec 12/27/1977}}*, Cache Estates Subdivision *{{ FRD Plat No. 1980-049, rec. 3/21/1980}}* and Motts Subdivision *{{FRD Plat No. 1992-025, rec. 2/20/1992}}* to the NW corner of Lot 7, Block 2 of the Foxridge Heights Subdivision *{{FRD Plat No. 2001-079, rec. 8/13/2001}}* where Cranberry Ridge Drive transitions to Crestline Drive
- Continuing easterly along Crestline Drive to the NW corner of Lot 9 of the Summer Ridge Subdivision *{{FRD Plat No. 1981-115, rec. 7/22/1981}}* where Crestline Drive meets Skyline Drive (formally Skyridge Drive)
- Then southeasterly on Skyline Drive to the NW corner TL-1418, Section 14, T1N, R1W, FM *{{FRD Inst. No. 2014-001625-0, rec. 2/15/2014}}*
- Then southeasterly along the northern boundary of TL-1418 to the NW corner of TL-1436, Section 14, T1N, R1W, FM *{{FRD Inst. No. 2017-020226-0, rec. 8/29/2007}}*
- Continuing southeasterly along the northern boundary of TL-1436 to the NW corner of TL-1416, Section 14, T1N, R1W, FM *{{FRD Book 133, Page 0453, rec. 12/19/1978}}*
- Continuing southeasterly along the northern boundary of TL-1416 to the NW corner of TL-1438, Section 14, T1N, R1W, FM *{{FRD Inst. No. 2010-023684-0, rec. 12/9/2010}}*
- Continuing southeasterly along the northern boundary of TL-1438 to the NW corner of TL-1439, Section 14, T1N, R1W, FM *{{FRD Inst. No. 2013-010209-0, rec. 6/7/2013}}*

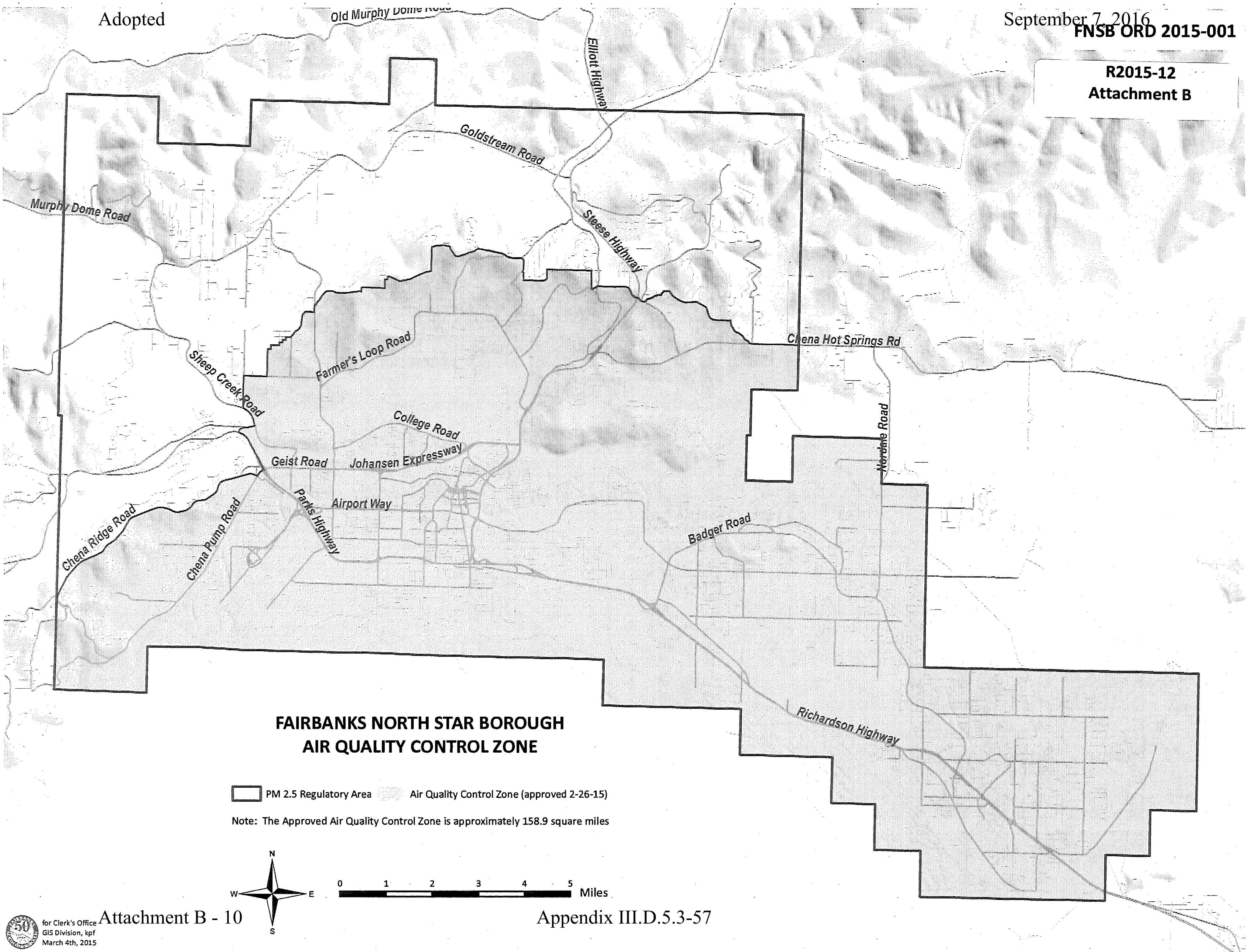
- Continuing southeasterly along the northern boundary of TL-1439 to the NW corner of TL-1407, Section 14, T1N, R1W, FM *{{FRD Book 1229, Page 663, rec. 11/27/2000}}*
- Continuing southeasterly along the northern boundary of TL-1407 to the NW corner of TL-1431, Section 14, T1N, R1W, FM *{{FRD Inst. No. 1988-011042-0, rec. 5/31/1988}}*
- Continuing southeasterly along the northern boundary of TL-1431 to its SE corner, which is a point on Skyline Drive
- Continuing easterly on Skyline Drive through the Fiess Subdivision *{{FRD Plat No. 1986-088, rec. 7/3/1986}}* to the NE corner of Lot 1, Block 1 of the Skylane Panorama Subdivision *{{FRD Plat No. 1974-103, rec. 9/26/1974}}* where Skyline Drive transitions to Linda Lou Lane
- Then southerly on Linda Lou Lane through the Skylane Panorama Subdivision to the NE corner of TL-1409, Section 14, T1N, R1W, FM *{{FRD Inst. No. 1987-027626-0, rec. 12/18/1987}}*
- Continuing southerly along the eastern boundary of TL-1409 to the NE corner of TL-1452, Section 14, T1N, R1W, FM *{{FRD Inst. No. 1987-027626-0, rec. 12/18/1987}}*
- Continuing southerly along the eastern boundary of TL-1452 to the NW corner of Lot 2 of the Wood Chopper Heights Subdivision, 1st Addition *{{ FRD Plat No. 2012-061, rec. 8/20/2012}}*
- Then easterly along the northern boundary of the Wood Chopper Heights Subdivision, 1st Addition to the NW corner of TL-1309, Section 13, T1N, R1W, FM *{{FRD Book 01246, Page 0161, rec. 3/27/2001}}*
- Continuing easterly along the northern boundary of TL-1309 to the NW corner of TL-1312, Section 13, T1N, R1W, FM *{{FRD Book 1067, Page 527, rec. 5/18/1998}}*
- Continuing easterly along the northern boundary of TL-1312 to the NW corner of Lot 1, Block G of the Sun Valley Estates Subdivision, 2nd *Addition {{FRD Plat No. 1983-120, rec. 7/18/1983}}*
- Continuing easterly along the northern boundary of the Sun Valley Estates Subdivision, 2nd Addition to the SE corner of Lot 329 of the McGrath Estates Subdivision, Portion 3 & 3A *{{FRD Plat No. 1982-053, rec. 4/16/1982}}* which is a point on Hawk Road.
- Then northeasterly on Hawk Road to the SW corner of Lot 205 of the McGrath Estates Subdivision, Portion 2 *{{FRD Plat No. 1977-016, rec. 2/8/1977}}*
- Then northerly along the western boundary of the McGrath Estates Subdivision, Portion 2 to the NW corner of Lot 202 of the McGrath Estates Subdivision, Portion 2

- Then easterly along the northern boundary of the McGrath Estates Subdivision, Portion 2 to the NW corner of Lot 1, Block C of the McGrath Estates Subdivision *{{FRD Plat No. 1976-031, rec. 4/29/1976}}*
- Continuing easterly along the northern boundary of the McGrath Estates Subdivision to the NW corner of TL-1314, Section 13, T1N, R1W, FM *{{FRD Book 1256, Page 137, rec. 5/11/2001}}*
- Continuing easterly along the northern boundary of TL-1314 to the NW corner of Lot 1A-1, Block 5 of the Sunny Hills Terrace Subdivision, 2nd Addition *{{FRD Plat No. 2013-063, rec. 6/27/2013}}*
- Continuing easterly along the northern boundary of Lot 1A-1 to the NW corner of Lot 3A, Block 5 of the Sunny Hills Terrace Subdivision, 2nd Addition *{{FRD Plat No. 2009-020, rec. 2/18/2009}}*
- Continuing easterly along the northern boundary of Lot 3A to the NW corner of Lot 4, Block 5 of the Sunny Hills Terrace Subdivision, 2nd Addition *{{FRD Plat No. 1965-6678, rec. 9/9/1968}}*
- Continuing easterly along the northern boundary of the Sunny Hills Terrace Subdivision, 2nd Addition to Broadview Drive.
- Then southerly on Broadview Drive to McGrath Road.
- Then northeasterly on McGrath Road to the intersection of Old Steese Highway and Hagelbarger Avenue.
- Continuing easterly on Hagelbarger Avenue through the Blueberry Ridge Subdivision *{{FRD Plat No. 1968-1771, rec. 3/1/1968}}*, the Grandview Subdivision *{{FRD Plat No. 1968-5868, rec. 6/27/1968}}*, the Cottonwood Hill Subdivision *{{FRD Plat No. 2014-043, rec. 4/10/2014 }}*, the Gackstetter Subdivision *{{FRD Plat No. 1980-054, rec 4/1/1980}}* and the Karella Subdivision *{{FRD Plat No. 1980-101, rec. 4/18/1980}}* to the intersection of the Steese Hwy and Bennett Rd
- Then southeasterly on Bennett Road to Steele Creek Road
- Then easterly on Steele Creek Road to a point on the southern boundary of TL-2029, T1N, R1E, FM *{{ FRD Book 463, Page 188, rec. 1/10/1986 }}*
- Then easterly along the southern boundary of TL-2029 to its NE corner, which is a point on the southern boundary of Section 17, T1N, R1E, FM
- Then easterly along the southern boundary of Section 17 to the SW corner of Section 16, T1N, R1E, FM

– Then northerly along the western boundary of Section 16 to a point on Steele Creek Road

– Then easterly on Steele Creek Road to Chena Hot Springs Road

– Then easterly on Chena Hot Springs Road to the *eastern boundary of the EPA designated non-attainment area.*


Elliott Highway
Goldstream Road
Murphy Dome Road
Steese Highway
Chena Hot Springs Rd
Farmer's Loop Road
Sheep Creek Road
College Road
Geist Road
Johansen Expressway
Airport Way
Parks Highway
Chena Ridge Road
Chena Pump Road
Badger Road
Richardson Highway
FAIRBANKS NORTH STAR BOROUGH
AIR QUALITY CONTROL ZONE
PM 2.5 Regulatory Area
Air Quality Control Zone (approved 2-26-15)
Note: The Approved Air Quality Control Zone is approximately 158.9 square miles
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Miles
for Clerk's Office
GIS Division, kpf
March 4th, 2015

Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.4

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

Adopted

December 24, 2014

Bill Walker
Governor

Larry Hartig
Commissioner

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Appendix III.D.5.4

Ambient Air Quality Data - Fairbanks $PM_{2.5}$ FRM data from 2005 through 2012 for the State Office Building site.

(This page serves as a placeholder for two-sided copying)

Fairbanks $PM_{2.5}$ FRM data from 2005 through 2012 for the State Office Building site				
AQS Qualifier Codes				
Cod e	**Description**	**Comments**	**Used for NAAQS compliance?**	
1	Deviation from CFR/Critical Criteria Requirement	usually a post-sample filter holding issue	Concentration is included in NAAQS compliance calculations	
2	Operational Deviation	usually a pre-sample filter holding issue	Concentration is included in NAAQS compliance calculations	
3	Field Issue	typically a QA issue	Concentration is included in NAAQS compliance calculations	
E	Forest Fire	old AQS qualifier flag, later changed to RT	Concentration is included in NAAQS compliance calculations	
P	Roofing operations		Concentration is included in NAAQS compliance calculations	
RT	Wildfire - US	same as E, name changed after 2006; an exceptional events waiver request has been submitted to EPA	Concentration will not be included in NAAQS compliance calculations once exceptional events waiver is granted.	
X	Filter temperature difference out of spec		Concentration is included in NAAQS compliance calculations	
Y	Elapsed sample time out of spec		Concentration is **not** included in NAAQS compliance calculations **unless** it is an **exceedance**	
AQS Null Codes				
Cod e	**Description**	**Used for NAAQS compliance?**		
AF	Scheduled but not collected	No		
AG	Sample time out of limits	No		
AJ	Filter damage	No		
AM	Miscellaneous void	No		
AN	Machine malfunction	No		
AQ	Collection Error	No		

Fairbanks State Office Building site $PM_{2.5}$ FRM data from 2005 through 2012						
Date [yyyymmdd]	**Date [m/d/yy]**	**Sample Value [ug/m³]**	**Null Data Code**	**Qualifier - 1**	**Qualifier - 2**	**Comments**
20050104	1/4/05	4.7				
20050110	1/10/05	28.9		3		Field Issue; Concentration is included in NAAQS compliance calculations
20050116	1/16/05	40.6		3		Field Issue; Concentration is included in NAAQS compliance calculations
20050122	1/22/05	32.7				
20050128	1/28/05	29.2		3		Field Issue; Concentration is included in NAAQS compliance calculations
20050203	2/3/05	60.0		2	X	Operational deviation, Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20050209	2/9/05	23.8				
20050215	2/15/05	15.7				
20050221	2/21/05	34.0				
20050227	2/27/05	6.1				
20050305	3/5/05	16.5				
20050311	3/11/05	8.5				
20050317	3/17/05	5.1				
20050323	3/23/05	6.7				
20050329	3/29/05	4.6				
20050404	4/4/05	5.4				
20050410	4/10/05	4.3				
20050416	4/16/05	4.5				
20050422	4/22/05	4.0				
20050428	4/28/05	7.1				
20050504	5/4/05	4.2				

20050510	5/10/05	5.0				
20050516	5/16/05	2.5				
20050522	5/22/05	4.6				
20050528	5/28/05	0.1				
20050603	6/3/05	2.9				
20050609	6/9/05	5.0				
20050615	6/15/05	8.7		2	X	Operational Deviation, Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20050621	6/21/05	16.0		E		Forest Fire, data point impacted by wildfire, requesting EPA exclude exception event from attainment calculations
20050627	6/27/05	28.9		E		Forest Fire, data point impacted by wildfire, requesting EPA exclude exception event from attainment calculations
20050703	7/3/05	4.6				
20050709	7/9/05	7.0				
20050715	7/15/05	5.3				
20050721	7/21/05	2.4				
20050727	7/27/05	33.5		E		Forest Fire, data point impacted by wildfire, requesting EPA exclude exception event from attainment calculations
20050802	8/2/05	20.6		E		Forest Fire, data point impacted by wildfire, requesting EPA exclude exception event from attainment calculations
20050808	8/8/05	32.1		E		Forest Fire, data point impacted by wildfire, requesting EPA exclude exception event from attainment calculations
20051001	10/1/05	0.3				
20051007	10/7/05	8.2		P		Roofing operations. Data point still used for calcualtion of compliance with the NAAQS
20051013	10/13/05	4.6		P		Roofing operations. Data point still used for calcualtion of compliance with the NAAQS
20051019	10/19/05	9.0				

20051025	10/25/05	4.0				
20051031	10/31/05	9.5				
20051106	11/6/05	12.7				
20051118	11/18/05	5.3				
20051124	11/24/05	6.8				
20051130	11/30/05	22.1				
20051206	12/6/05	18.3				
20051208	12/8/05	14.3				
20051212	12/12/05	5.2				
20051218	12/18/05	28.7				
20051224	12/24/05	25.9				
20051230	12/30/05	32.8				
20060105	1/5/06	38.0				
20060111	1/11/06	42.2				
20060117	1/17/06	51.9				
20060123	1/23/06	27.6				
20060129	1/29/06	32.7		3	X	Field Issue. Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20060204	2/4/06	41.1				
20060210	2/10/06	6.2				
20060216	2/16/06	12.6				
20060222	2/22/06	5.4				
20060228	2/28/06	13.4				
20060306	3/6/06	13.3				

20060312	3/12/06	8.3				
20060318	3/18/06	10.1				
20060324	3/24/06	5.4				
20060330	3/30/06	13.4				
20060405	4/5/06	4.7				
20060411	4/11/06	3.3				
20060417	4/17/06	6.2				
20060426	4/26/06	5.7				
20060429	4/29/06	4.3				
20060505	5/5/06	3.7				
20060511	5/11/06	4.3				
20060517	5/17/06	4.5				
20060523	5/23/06	4.0				
20060529	5/29/06	4.6				
20060604	6/4/06	1.2				
20060610	6/10/06	12.5				
20060616	6/16/06	27.4				
20060622	6/22/06	4.2		1		Deviation from CFR/Critical Criteria Requirement; usually a post-sample filter holding issue; Concentration is included in NAAQS compliance calculations
20060628	6/28/06	4.1				
20060704	7/4/06	4.0				
20060710	7/10/06	2.7				
20060716	7/16/06	1.7				

20060722	7/22/06	4.6				
20060728	7/28/06	3.8				
20060803	8/3/06	2.9				
20060809	8/9/06	4.0				
20060815	8/15/06	2.0				
20060821	8/21/06	2.0				
20060827	8/27/06	3.0				
20060902	9/2/06	2.5				
20060908	9/8/06	4.9				
20060914	9/14/06	6.0				
20060920	9/20/06	4.0				
20060926	9/26/06	6.2				
20061002	10/2/06	8.9				
20061008	10/8/06	5.4				
20061014	10/14/06	7.6				
20061020	10/20/06	10.0				
20061026	10/26/06	3.2				
20061101	11/1/06	4.2				
20061107	11/7/06	11.5				
20061113	11/13/06	22.8				
20061119	11/19/06	23.7				
20061201	12/1/06	7.3				
20061207	12/7/06	22.8				

20061213	12/13/06	13.2				
20061219	12/19/06	32.1				
20061225	12/25/06	8.4				
20061231	12/31/06	19.1				
20070106	1/6/07	17.7				
20070112	1/12/07	26.7				
20070118	1/18/07	21.5				
20070121	1/21/07	22.3				
20070127	1/27/07	29.6				
20070130	1/30/07	21.6				
20070202	2/2/07	22.3				
20070208	2/8/07	14.7				
20070211	2/11/07	12.4				
20070214	2/14/07	17.0				
20070220	2/20/07	29.7		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20070223	2/23/07	33.1		3		Field Issue; Concentration is included in NAAQS compliance calculations
20070226	2/26/07	13.7				
20070307	3/7/07	6.0		Y		Elapsed sample time out of spec; Concentration **is not** included in NAAQS compliance calculations
20070310	3/10/07	8.7		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20070316	3/16/07	11.9				
20070319	3/19/07	13.4				
20070322	3/22/07	5.0				

20070328	3/28/07	16.4				
20070331	3/31/07	12.3				
20070406	4/6/07	5.6				
20070412	4/12/07	5.1				
20070415	4/15/07	3.7				
20070418	4/18/07	6.7				
20070421	4/21/07	5.7				
20070424	4/24/07	3.7				
20070427	4/27/07	3.4		1		Deviation from CFR/Critical Criteria Requirement; usually a post-sample filter holding issue; Concentration is included in NAAQS compliance calculations
20070430	4/30/07	4.7		1		Deviation from CFR/Critical Criteria Requirement; usually a post-sample filter holding issue; Concentration is included in NAAQS compliance calculations
20070503	5/3/07	3.7				
20070506	5/6/07	2.7				
20070509	5/9/07	4.9				
20070512	5/12/07	3.0				
20070515	5/15/07	2.1				
20070518	5/18/07	4.1				
20070521	5/21/07	4.7				
20070524	5/24/07	2.0				
20070527	5/27/07	6.5				
20070530	5/30/07	3.0				
20070602	6/2/07	4.1				

20070611	6/11/07	4.5				
20070614	6/14/07	4.0				
20070617	6/17/07	3.8				
20070620	6/20/07	5.2				
20070623	6/23/07	12.4				
20070626	6/26/07	1.7				
20070629	6/29/07	5.6				
20070702	7/2/07	8.8				
20070705	7/5/07	5.7				
20070708	7/8/07	5.3				
20070711	7/11/07	1.7				
20070714	7/14/07	1.9				
20070717	7/17/07	3.0				
20070720	7/20/07	4.5				
20070723	7/23/07	3.2				
20070726	7/26/07	4.7				
20070729	7/29/07	2.8				
20070801	8/1/07	2.7				
20070804	8/4/07	2.4				
20070807	8/7/07	1.7				
20070810	8/10/07	4.2				
20070813	8/13/07	1.4				
20070816	8/16/07	4.7				

20070819	8/19/07	3.5				
20070822	8/22/07	3.3				
20070825	8/25/07	3.0				
20070828	8/28/07	4.3				
20070831	8/31/07	5.7				
20070903	9/3/07	3.5				
20070906	9/6/07	4.5				
20070909	9/9/07	3.9				
20070912	9/12/07	5.1				
20070915	9/15/07	2.5				
20070918	9/18/07	6.2				
20070921	9/21/07	3.7				
20070924	9/24/07	8.3				
20070927	9/27/07	4.0				
20070930	9/30/07	8.8				
20071003	10/3/07	2.1				
20071006	10/6/07	3.0				
20071009	10/9/07	5.8				
20071012	10/12/07	13.2				
20071015	10/15/07	12.5				
20071018	10/18/07	10.7				
20071021	10/21/07	13.8				
20071024	10/24/07	6.5				

20071027	10/27/07	14.6				
20071030	10/30/07	18.6				
20071102	11/2/07	8.9				
20071105	11/5/07	21.5				
20071108	11/8/07	10.9				
20071111	11/11/07	22.7				
20071114	11/14/07	26.2				
20071117	11/17/07	8.2				
20071120	11/20/07	17.7				
20071123	11/23/07	10.7				
20071126	11/26/07	12.5		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20071129	11/29/07	29.6				
20071202	12/2/07	4.3				
20071205	12/5/07	19.6				
20071208	12/8/07	17.3				
20071211	12/11/07	10.8				
20071214	12/14/07	4.0				
20071217	12/17/07	26.7				
20071220	12/20/07	51.6				
20071223	12/23/07	33.0				
20071226	12/26/07	12.2				
20071229	12/29/07	17.2				
20080101	1/1/08	23.7				

20080104	1/4/08	10.8				
20080107	1/7/08	19.8				
20080110	1/10/08	6.6				
20080113	1/13/08	7.7				
20080116	1/16/08	21.5				
20080119	1/19/08	25.9				
20080122	1/22/08	6.5				
20080125	1/25/08	17.5				
20080128	1/28/08	19.5				
20080131	1/31/08		AG	Y		Sample time out of limits- filter did not run the required time; Elapsed sample time out of spec
20080203	2/3/08	23.5				
20080206	2/6/08		AG	Y		Sample time out of limits- filter did not run the required time; Elapsed sample time out of spec
20080209	2/9/08	40.4				
20080215	2/15/08	8.1				
20080218	2/18/08	12.7				
20080221	2/21/08	7.1				
20080224	2/24/08	7.2				
20080227	2/27/08	17.4				
20080301	3/1/08	5.0				
20080304	3/4/08	23.4				
20080307	3/7/08	5.0				
20080313	3/13/08	9.7				
20080316	3/16/08	2.8				

20080319	3/19/08	5.3				
20080322	3/22/08	9.0				
20080325	3/25/08	5.2				
20080328	3/28/08	7.2				
20080331	3/31/08	5.2				
20080403	4/3/08	5.5				
20080406	4/6/08	5.7				
20080409	4/9/08	6.9				
20080412	4/12/08	7.0				
20080415	4/15/08	4.8				
20080418	4/18/08	8.6				
20080421	4/21/08	14.4				
20080424	4/24/08	10.0				
20080427	4/27/08	2.7				
20080430	4/30/08	3.2				
20080503	5/3/08	2.9				
20080506	5/6/08	3.8				
20080509	5/9/08	3.7				
20080512	5/12/08	2.8				
20080515	5/15/08	2.1				
20080518	5/18/08	2.2				
20080521	5/21/08	2.2				
20080524	5/24/08	3.6				

20080527	5/27/08	2.5				
20080530	5/30/08	2.3				
20080602	6/2/08	5.1				
20080605	6/5/08	1.6				
20080608	6/8/08	2.9				
20080611	6/11/08	3.6				
20080614	6/14/08	3.2				
20080617	6/17/08	2.4				
20080620	6/20/08	3.8				
20080623	6/23/08	2.1				
20080626	6/26/08	3.1				
20080629	6/29/08	1.1				
20080702	7/2/08	2.4				
20080705	7/5/08	6.4				
20080708	7/8/08	3.0				
20080711	7/11/08	8.1				
20080714	7/14/08	2.1				
20080717	7/17/08	2.7				
20080720	7/20/08	1.0				
20080723	7/23/08	2.1				
20080726	7/26/08	2.4				
20080729	7/29/08	1.5				
20080801	8/1/08	2.7				

20080804	8/4/08	3.1				
20080807	8/7/08	2.1				
20080810	8/10/08	1.0				
20080813	8/13/08	1.8				
20080816	8/16/08	2.7				
20080819	8/19/08	2.3				
20080822	8/22/08	2.5				
20080825	8/25/08	3.1				
20080828	8/28/08	3.1				
20080831	8/31/08	4.0				
20080903	9/3/08	4.6				
20080906	9/6/08	3.5				
20080909	9/9/08	5.0				
20080912	9/12/08	2.8				
20080915	9/15/08	2.4				
20080918	9/18/08	7.1				
20080921	9/21/08	4.5				
20080924	9/24/08	7.8				
20080927	9/27/08	3.8				
20080930	9/30/08	4.2				
20081003	10/3/08	1.4				
20081006	10/6/08	4.0				
20081009	10/9/08	5.7				

20081012	10/12/08	0.8				
20081015	10/15/08	7.6				
20081018	10/18/08	17.6				
20081021	10/21/08	6.1				
20081024	10/24/08	4.6				
20081027	10/27/08	9.3				
20081030	10/30/08	32.6				
20081102	11/2/08	15.5				
20081105	11/5/08	40.4				
20081108	11/8/08	37.0				
20081111	11/11/08	27.4				
20081114	11/14/08	50.7				
20081117	11/17/08	20.0				
20081120	11/20/08	17.5				
20081123	11/23/08	23.6				
20081126	11/26/08	21.7				
20081129	11/29/08	14.6				
20081202	12/2/08	46.7				
20081205	12/5/08	27.1				
20081208	12/8/08	26.5				
20081211	12/11/08	18.8				
20081214	12/14/08	38.3				
20081217	12/17/08	34.0				

20081220	12/20/08	25.7				
20081223	12/23/08	29.1				
20081226	12/26/08	16.3				
20081229	12/29/08	114.5		3	Y	Field Issue. Elapsed sample time out of spec. Because this is an exceedance, concentration **will be** used for calculation of compliance with the NAAQS
20090101	1/1/09	27.7		X		Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20090104	1/4/09	39.0		X		Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20090107	1/7/09	59.0		X		Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20090110	1/10/09	52.7		X		Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20090113	1/13/09	29.1				
20090116	1/16/09	2.5				
20090119	1/19/09	10.5				
20090122	1/22/09	5.3				
20090125	1/25/09	26.2				
20090128	1/28/09		AJ			Filter damage
20090131	1/31/09	13.5				
20090203	2/3/09	19.9		X		Filter temperature difference out of spec. Concentration is included in NAAQS compliance calculations
20090206	2/6/09	28.5				
20090209	2/9/09	11.5				
20090212	2/12/09	16.8				
20090215	2/15/09	28.0				

20090218	2/18/09	22.5				
20090221	2/21/09	15.5				
20090224	2/24/09	19.8				
20090227	2/27/09	7.8				
20090302	3/2/09	16.2				
20090305	3/5/09	5.7				
20090308	3/8/09	9.5				
20090311	3/11/09	15.5				
20090314	3/14/09	13.8				
20090317	3/17/09	9.1				
20090320	3/20/09	5.0				
20090323	3/23/09	9.2				
20090326	3/26/09	4.5				
20090329	3/29/09	9.7				
20090401	4/1/09	9.5				
20090404	4/4/09	6.6				
20090407	4/7/09	10.1				
20090410	4/10/09	7.2				
20090413	4/13/09	4.8				
20090416	4/16/09	6.0				
20090419	4/19/09	7.5				
20090422	4/22/09	8.5				
20090425	4/25/09	3.2				

20090428	4/28/09	5.6				
20090501	5/1/09	8.8				
20090504	5/4/09	7.1				
20090507	5/7/09		AF			Filter scheduled but not collected
20090510	5/10/09	3.2				
20090513	5/13/09	4.7				
20090516	5/16/09	3.0				
20090519	5/19/09	6.6				
20090522	5/22/09	6.6				
20090525	5/25/09		AF			Filter scheduled but not collected
20090528	5/28/09	3.2				
20090531	5/31/09	4.2				
20090603	6/3/09	8.5				
20090606	6/6/09	3.9				
20090609	6/9/09	19.5		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20090612	6/12/09	9.9				
20090615	6/15/09	5.0				
20090618	6/18/09	6.6				
20090621	6/21/09	3.7				
20090624	6/24/09	3.4				
20090627	6/27/09	3.1				
20090630	6/30/09	4.1				
20090703	7/3/09	8.0				

20090706	7/6/09	44.1		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090709	7/9/09	19.3		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090712	7/12/09	8.4		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20090715	7/15/09	75.3		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090718	7/18/09	10.3				
20090721	7/21/09	7.7				
20090724	7/24/09	17.7		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090727	7/27/09	25.6		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090730	7/30/09	159.5		RT	Y	Elapsed sample time out of spec; Because this is an exceedance, data point **will be** used for calculation of compliance with the NAAQS; Wildfire - US, data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090802	8/2/09	89.7		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090805	8/5/09	127.7		RT	Y	Elapsed sample time out of spec; Because this is an exceedance, data point **will be** used for calculation of compliance with the NAAQS; Wildfire - US, data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090808	8/8/09	61.0		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from NAAQS compliance calculations
20090811	8/11/09	3.2				
20090814	8/14/09	5.1				
20090817	8/17/09	4.7				

20090820	8/20/09	3.5				
20090823	8/23/09	4.1				
20090826	8/26/09	4.4				
20090829	8/29/09	4.1				
20090901	9/1/09	2.6				
20090904	9/4/09	6.4				
20090907	9/7/09	5.0				
20090910	9/10/09	4.0				
20090913	9/13/09	3.4				
20090916	9/16/09	3.2				
20090919	9/19/09	1.2				
20090922	9/22/09	2.0				
20090925	9/25/09	2.2				
20090928	9/28/09	2.2				
20091001	10/1/09	3.7				
20091004	10/4/09	9.3				
20091007	10/7/09	1.6				
20091010	10/10/09	9.7				
20091013	10/13/09	13.5				
20091016	10/16/09	15.5				
20091019	10/19/09	10.9				
20091022	10/22/09	17.2				
20091025	10/25/09	20.4				

20091028	10/28/09	7.7				
20091031	10/31/09	4.0				
20091103	11/3/09	14.6				
20091106	11/6/09	5.5				
20091109	11/9/09	14.2				
20091112	11/12/09	4.4				
20091115	11/15/09	17.0				
20091118	11/18/09		AM	X		Miscellaneous void; Filter temperature difference out of spec
20091121	11/21/09	26.2				
20091124	11/24/09	35.3				
20091127	11/27/09	21.3				
20091130	11/30/09	14.3				
20091203	12/3/09	9.1				
20091206	12/6/09	25.1				
20091209	12/9/09	51.0				
20091212	12/12/09	40.8				
20091215	12/15/09	6.5				
20091218	12/18/09	4.0				
20091221	12/21/09	41.5				
20091224	12/24/09	0.6				
20091227	12/27/09	25.2				
20091230	12/30/09	43.1				
20100102	1/2/10	51.8				

20100105	1/5/10	51.8				
20100108	1/8/10	44.4				
20100111	1/11/10	36.9				
20100114	1/14/10		AJ	X		Filter damage; Filter temperature difference out of spec
20100117	1/17/10	17.1				
20100120	1/20/10	38.1				
20100126	1/26/10	83.2				
20100129	1/29/10	27.4				
20100201	2/1/10	28.8		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20100204	2/4/10	31.5				
20100207	2/7/10	14.5				
20100210	2/10/10	22.6				
20100213	2/13/10	30.9				
20100216	2/16/10	26.0				
20100219	2/19/10	22.3				
20100222	2/22/10	12.6				
20100225	2/25/10	3.3				
20100228	2/28/10	9.5				
20100303	3/3/10	21.1				
20100306	3/6/10	3.9				
20100309	3/9/10	2.9				
20100312	3/12/10	8.9				
20100315	3/15/10	8.2				

20100318	3/18/10	12.8				
20100321	3/21/10	9.1				
20100324	3/24/10	3.2				
20100327	3/27/10	5.9				
20100330	3/30/10	5.8				
20100402	4/2/10	4.7				
20100405	4/5/10	8.4				
20100408	4/8/10	2.8				
20100411	4/11/10	5.5				
20100414	4/14/10	4.0				
20100417	4/17/10	4.3				
20100420	4/20/10	2.6				
20100423	4/23/10	4.1				
20100426	4/26/10	3.6				
20100429	4/29/10	6.6				
20100502	5/2/10	2.2				
20100505	5/5/10	3.3		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20100508	5/8/10	4.9		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20100511	5/11/10	3.8				
20100514	5/14/10	4.0				
20100517	5/17/10	3.0				
20100520	5/20/10	2.9				

20100523	5/23/10	9.9				
20100526	5/26/10	4.8				
20100529	5/29/10	21.8		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20100601	6/1/10	23.4		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20100607	6/7/10	9.8				
20100610	6/10/10	4.8		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20100613	6/13/10	3.2				
20100619	6/19/10	9.2		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20100622	6/22/10	5.1		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20100625	6/25/10	8.0				
20100701	7/1/10	5.7				
20100704	7/4/10	3.6				
20100707	7/7/10	2.6				
20100710	7/10/10	4.9				
20100713	7/13/10	44.5		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20100716	7/16/10	21.3		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20100719	7/19/10	4.8				
20100722	7/22/10	2.0				
20100725	7/25/10	3.2				
20100728	7/28/10	4.0		1		Deviation from CFR/Critical Criteria Requirement; usually a filter holding issue;

						Concentration is included in NAAQS compliance calculations
20100731	7/31/10	5.7		1		Deviation from CFR/Critical Criteria Requirement; usually a filter holding issue; Concentration is included in NAAQS compliance calculations
20100803	8/3/10	10.1		1		Deviation from CFR/Critical Criteria Requirement; usually a filter holding issue; Concentration is included in NAAQS compliance calculations
20100806	8/6/10	5.2				
20100809	8/9/10	3.1				
20100812	8/12/10	10.9				
20100815	8/15/10	2.0				
20100818	8/18/10	1.3				
20100821	8/21/10	5.0				
20100824	8/24/10	5.6				
20100827	8/27/10	5.0				
20100830	8/30/10	2.7				
20100902	9/2/10	5.1				
20100905	9/5/10	4.0				
20100908	9/8/10	1.8		1		Deviation from CFR/Critical Criteria Requirement; usually a filter holding issue; Concentration is included in NAAQS compliance calculations
20100911	9/11/10	5.5				
20100914	9/14/10	8.0				
20100917	9/17/10	10.4				
20100920	9/20/10	7.1				
20100923	9/23/10	1.6				

20100926	9/26/10	5.5				
20100929	9/29/10	8.2				
20101002	10/2/10	9.6				
20101005	10/5/10	8.8				
20101008	10/8/10	9.5				
20101011	10/11/10	10.8				
20101014	10/14/10	5.3				
20101017	10/17/10	9.2				
20101020	10/20/10	17.0				
20101023	10/23/10	6.6				
20101026	10/26/10	9.3				
20101029	10/29/10	4.8				
20101101	11/1/10	14.5				
20101104	11/4/10	3.5				
20101107	11/7/10	9.6				
20101110	11/10/10	9.2				
20101113	11/13/10	8.0				
20101116	11/16/10	22.7				
20101119	11/19/10	18.8				
20101122	11/22/10	11.6				
20101125	11/25/10	2.2				
20101128	11/28/10	14.6				
20101201	12/1/10	41.2		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations

20101204	12/4/10	6.7				
20101207	12/7/10	36.9		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20101210	12/10/10	25.2				
20101213	12/13/10	15.3				
20101216	12/16/10	57.1				
20101219	12/19/10	36.7				
20101222	12/22/10	30.2				
20101225	12/25/10	25.6				
20101228	12/28/10	7.1				
20101231	12/31/10	9.0				
20110103	1/3/11	23.4				
20110106	1/6/11	10.5				
20110109	1/9/11	24.9				
20110112	1/12/11	34.9				
20110115	1/15/11	28.5				
20110118	1/18/11	38.0				
20110121	1/21/11	28.8				
20110124	1/24/11	13.9				
20110127	1/27/11	18.4				
20110130	1/30/11	28.9				
20110202	2/2/11	21.3				
20110205	2/5/11	36.0				
20110208	2/8/11	32.2				

20110211	2/11/11	6.4				
20110214	2/14/11	2.3				
20110217	2/17/11	28.5				
20110220	2/20/11	15.8				
20110223	2/23/11	23.7				
20110226	2/26/11	10.0				
20110301	3/1/11	42.6		1		Deviation from CFR/Critical Criteria Requirement; usually a filter holding issue; Concentration is included in NAAQS compliance calculations
20110304	3/4/11	18.8				
20110307	3/7/11	17.1				
20110310	3/10/11	13.6				
20110313	3/13/11	12.7				
20110316	3/16/11	11.9				
20110319	3/19/11	14.9				
20110322	3/22/11	14.3				
20110325	3/25/11	8.4				
20110328	3/28/11	3.0				
20110331	3/31/11	5.2				
20110403	4/3/11	7.3				
20110406	4/6/11	4.7				
20110409	4/9/11	4.0				
20110412	4/12/11	4.3				
20110415	4/15/11	6.9				

20110418	4/18/11	5.1				
20110421	4/21/11	4.7				
20110424	4/24/11	4.8				
20110427	4/27/11	2.8				
20110430	4/30/11	4.7				
20110503	5/3/11	3.3				
20110506	5/6/11	4.1				
20110509	5/9/11	5.1				
20110512	5/12/11	3.0				
20110515	5/15/11	4.7				
20110518	5/18/11	4.7				
20110521	5/21/11	5.5				
20110524	5/24/11	5.0				
20110527	5/27/11	8.7				
20110530	5/30/11	11.6				
20110602	6/2/11	3.7				
20110605	6/5/11	2.8				
20110608	6/8/11	22.4				
20110611	6/11/11	3.2				
20110614	6/14/11	1.7				
20110617	6/17/11	3.1				
20110620	6/20/11	3.5				
20110623	6/23/11	2.1				

20110626	6/26/11	4.5				
20110629	6/29/11	2.5				
20110702	7/2/11	2.9				
20110705	7/5/11	2.1				
20110708	7/8/11	4.2				
20110711	7/11/11	3.2				
20110714	7/14/11	3.0				
20110717	7/17/11	2.6				
20110720	7/20/11	2.6				
20110723	7/23/11	4.3				
20110726	7/26/11	3.7				
20110729	7/29/11	3.2				
20110801	8/1/11	2.2				
20110804	8/4/11	3.0				
20110807	8/7/11	1.7				
20110810	8/10/11	1.0				
20110813	8/13/11	2.2				
20110816	8/16/11	1.4				
20110819	8/19/11	1.6				
20110822	8/22/11	2.7				
20110825	8/25/11	4.0				
20110828	8/28/11	3.6				
20110831	8/31/11	3.5				

20110903	9/3/11	3.3				
20110906	9/6/11	1.6				
20110909	9/9/11	2.7				
20110912	9/12/11	4.6				
20110915	9/15/11	3.5		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20110918	9/18/11	4.0				
20110921	9/21/11	3.7				
20110924	9/24/11	1.6				
20110927	9/27/11	3.6				
20110930	9/30/11	7.7				
20111003	10/3/11	7.2				
20111006	10/6/11	9.7				
20111009	10/9/11	3.8				
20111012	10/12/11	6.8		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20111015	10/15/11	8.5		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20111018	10/18/11	3.0				
20111021	10/21/11	13.7				
20111024	10/24/11	15.4				
20111027	10/27/11	11.5				
20111030	10/30/11	7.0				
20111102	11/2/11	11.0				

20111105	11/5/11	5.4		2		Operational deviation; usually a filter holding time issue; Concentration is included in NAAQS compliance calculations
20111108	11/8/11	9.7				
20111111	11/11/11	8.6				
20111114	11/14/11	25.2				
20111117	11/17/11	33.5				
20111120	11/20/11	41.0				
20111123	11/23/11	12.2				
20111126	11/26/11	23.2				
20111129	11/29/11	24.2				
20111202	12/2/11	13.3				
20111205	12/5/11	4.4				
20111208	12/8/11	25.6				
20111211	12/11/11	11.6				
20111214	12/14/11	24.8				
20111217	12/17/11	34.7		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20111220	12/20/11	11.3		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20111223	12/23/11	5.5				
20111226	12/26/11	23.5				
20111229	12/29/11	31.0				
20120101	1/1/12	21.0		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120104	1/4/12	12.5		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations

20120107	1/7/12	14.3		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120110	1/10/12	20.2		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120113	1/13/12	23.0		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120116	1/16/12	28.8		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120119	1/19/12	34.7		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120122	1/22/12	2.4				
20120125	1/25/12	8.5		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120128	1/28/12	38.2		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120131	1/31/12	19.1		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
20120203	2/3/12	6.4				
20120206	2/6/12	22.8				
20120209	2/9/12	15.6				
20120212	2/12/12	15.7				
20120215	2/15/12	25.7				
20120218	2/18/12	24.0				
20120221	2/21/12	15.4				
20120224	2/24/12	4.1				
20120227	2/27/12	2.7				
20120301	3/1/12	8.7				

2012030 4	3/4/12	12.7				
2012030 7	3/7/12	6.4				
2012031 0	3/10/1 2	9.0		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
2012031 3	3/13/1 2	12.7				
2012031 6	3/16/1 2	15.4				
2012031 9	3/19/1 2	10.4		X		Filter temperature difference out of spec; Concentration is included in NAAQS compliance calculations
2012032 2	3/22/1 2	12.2				
2012032 5	3/25/1 2	10.6				
2012032 8	3/28/1 2	7.4				
2012040 3	4/3/12	6.1				
2012040 6	4/6/12	3.5				
2012040 9	4/9/12		AN		Y	Machine malfunction; Elapsed time out of spec
2012041 2	4/12/1 2	7.0				
2012041 8	4/18/1 2	5.7				
2012042 1	4/21/1 2	4.2				
2012042 4	4/24/1 2	3.3				
2012042 7	4/27/1 2	4.4				
2012043 0	4/30/1 2	3.6				
2012050 3	5/3/12	4.5				
2012050 6	5/6/12	3.3				
2012050 9	5/9/12	2.5				
2012051 2	5/12/1 2	2.6				

20120515	5/15/12	1.7				
20120518	5/18/12	2.7				
20120521	5/21/12	3.2				
20120524	5/24/12	3.0				
20120527	5/27/12	1.2				
20120530	5/30/12	2.1				
20120602	6/2/12	0.1				
20120605	6/5/12	0.1				
20120608	6/8/12	0.2				
20120611	6/11/12	0.2				
20120614	6/14/12	2.3				
20120617	6/17/12	0.2				
20120620	6/20/12	0.2				
20120623	6/23/12	0.1				
20120626	6/26/12	0.0				
20120629	6/29/12	0.0				
20120702	7/2/12	3.5				
20120705	7/5/12	2.2				
20120708	7/8/12	0.9				
20120711	7/11/12	0.0				
20120714	7/14/12	0.2				
20120717	7/17/12		AQ			Collection Error
20120720	7/20/12	0.0				

20120723	7/23/12		AQ			Collection Error
20120726	7/26/12	0.1				
20120729	7/29/12	3.6				
20120801	8/1/12	3.3				
20120804	8/4/12	2.5				
20120807	8/7/12	3.0				
20120810	8/10/12	3.7				
20120813	8/13/12	6.3				
20120816	8/16/12	4.1				
20120819	8/19/12	14.8		RT		Wildfire - US; data point impacted by wildfire; requesting EPA exclude exception event from attainment calculations
20120822	8/22/12	0.1				
20120825	8/25/12	2.0				
20120828	8/28/12	1.7				
20120831	8/31/12	1.5				
20120903	9/3/12	3.5				
20120906	9/6/12	1.2				
20120909	9/9/12	3.0				
20120912	9/12/12	4.5				
20120915	9/15/12	5.3				
20120918	9/18/12	5.2				
20120921	9/21/12	3.7				
20120924	9/24/12	3.5				
20120927	9/27/12	4.4				

20120930	9/30/12	4.4				
20121003	10/3/12	4.4				
20121006	10/6/12	4.8				
20121009	10/9/12	3.7				
20121012	10/12/12	6.6				
20121018	10/18/12	5.8				
20121021	10/21/12	7.3				
20121024	10/24/12	28.2				
20121027	10/27/12	16.8				
20121030	10/30/12	17.2				
20121102	11/2/12	14.2				
20121105	11/5/12	20.3				
20121108	11/8/12	35.9				
20121111	11/11/12	12.7				
20121114	11/14/12	22.6				
20121117	11/17/12	3.4				
20121120	11/20/12	29.4				
20121123	11/23/12	20.3				
20121126	11/26/12	55.5				
20121129	11/29/12	49.6				
20121202	12/2/12	31.2				
20121205	12/5/12	28.6				
20121208	12/8/12	23.5				

20121211	12/11/12	5.4				
20121214	12/14/12	10.2				
20121217	12/17/12	52.1				
20121220	12/20/12	47.1				
20121223	12/23/12	41.7				
20121226	12/26/12	27.7				
20121229	12/29/12	27.2				

Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.5

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

Adopted

December 24, 2014

Bill Walker
Governor

Larry Hartig
Commissioner

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Appendix III.D.5.5

ADEC Annual Air Quality Monitoring Network Plan 2014-2015.

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Alaska Department of Environmental Conservation Annual Air Quality Monitoring Network Plan 2014 - 2015

August 29, 2014

Final Plan

Air Quality Division

Air Monitoring
&
Quality Assurance
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EXECUTIVE SUMMARY

The Alaska Department of Environmental Conservation (DEC) annual network plan for the 2014 – 2015 air quality monitoring program has remained in a similar format as last year's plan. The network information has been made more accessible to EPA reviewers by summarizing the regulatory details into tables and figures with a brief discussion to provide clarification.

The State monitoring priorities have remained the same.

There have been only minor changes to the monitoring sites since the issuance of last year's plan. The PM_{10} Hi-Volume sampler at the Municipality of Anchorage, Garden Site was removed at the end of December 2013. The site's PM_{10} Beta Attenuation Monitor (BAM) became the primary instrument. The ammonia analyzer at the Fairbanks North Star Borough (FNSB) NCORE site failed to provide quality data, was removed from service in February 2014, and was replaced with a new trace-level $NO_2/NO_X/NO$ analyzer. Both of these actions were anticipated and addressed in the 2013 -2014 Network plan.

Currently, DEC is not actively engaged in monitoring for airborne lead (Pb). The source-oriented Pb monitoring program intended from the Red Dog Mine is not feasible due to the remote and rugged terrain. DEC is currently working with the EPA on a modelling approach and is awaiting new soil samples for the development of new emission inventory data for the mine.

In continuing efforts to develop control strategies to resolve $PM_{2.5}$ non-attainment, the DEC and FNSB monitoring programs propose a number of network modifications. These changes will improve efficiency and the cost-effective use of monitoring equipment and personnel resources, while continuing to assess pollutant concentrations and to further characterize local atmospheric chemistry. DEC and FNSB are again requesting approval to relocate the chemical speciation sampler from the State Office Building to the NCORE site and shutting down the CO site at the Old Post Office Building. Further detail and technical justification for these modifications are presented in Section 4. The FNSB is also planning to use their mobile monitoring system (sniffer technology) to further evaluate the North Pole Fire #3 site to determine if the site is a hot spot or truly representative of a larger neighborhood scale.

To further support monitoring efforts in rural Alaska DEC proposes $PM_{2.5}$ monitoring programs in Yakutat.

1 INTRODUCTION

The Code of Federal Regulations (CFR) Title 40 §58.10 requires each state agency to adopt and submit to the U.S. Environmental Protection Agency (EPA) Regional Administrator an annual monitoring network plan which shall provide for the establishment and maintenance of an air quality surveillance system that consists of a network made up of the following types of monitoring stations:

- state and local air monitoring stations (SLAMS) including monitors that use:
  - federal reference method (FRM), or
  - federal equivalent method (FEM)
- multi-pollutant stations (NCORE)
- $PM_{2.5}$ chemical speciation network stations (CSN), and
- special purpose monitoring (SPM) stations.

The plan shall include a statement of purposes for each monitor and evidence that siting and operation of each monitor meets the requirements of appendices A, C, D, and E of 40 CFR 58 where applicable.

The annual monitoring network plan must be made available for public inspection for at least 30 days prior to submission to EPA. Any annual monitoring network plan that proposes SLAMS network modifications including new monitoring sites is subject to the approval of the EPA Regional Administrator, who shall provide opportunity for public comment and shall approve or disapprove the plan and schedule within 120 days. If the State or local agency has already provided a public comment opportunity on its plan and has made no changes subsequent to that comment opportunity, and has submitted the received comments together with the plan, the Regional Administrator is not required to provide a separate opportunity for comment.

The 2014-2015 plan shall include all required stations to be operational by July 1, 2014. Specific locations for the required monitors shall be included in the annual network plan submitted to the EPA Regional Administrator by July 1, 2014.

The annual monitoring network plan must contain the following information for each existing and proposed site:

1. The AQS site identification number.
2. The location, including street address and geographical coordinates.
3. The sampling and analysis method(s) for each measured parameter.
4. The operating schedules for each monitor.
5. Any proposals to remove or move a monitoring station within a period of 18 months following plan submittal.
6. The minimum monitoring requirements for spatial scale of representativeness for each monitor as defined in 40 CFR 58, Appendix D.
7. The minimum monitoring requirements for probe and monitoring path siting criteria as defined in 40 CFR 58, Appendix E.

8. The identification of any sites that are suitable and sites that are not suitable for comparison against the annual $PM_{2.5}$ NAAQS as described in 40 CFR 58.30.
9. The MSA, CBSA, CSA or other area represented by the monitor.
10. The designation of any lead monitors as either source-oriented or non-source-oriented according to 40 CFR 58, Appendix D.
11. Any source-oriented monitors for which a waiver has been requested or granted by the EPA Regional Administrator as allowed for under paragraph 4.5(a)(ii) of 40 CFR 58, Appendix D.
12. Any source-oriented or non-source-oriented site for which a waiver has been requested or granted by the EPA Regional Administrator for the use of Pb-PM_{10} monitoring in lieu of Pb-TSP monitoring as allowed for under paragraph 2.10 of 40 CFR 58, Appendix C.

2 AIR QUALITY MONITORING PRIORITIES

In 1970 the Congress of the United States created the U.S. Environmental Protection Agency (EPA) and promulgated the Clean Air Act (CAA). Title I of the CAA established National Ambient Air Quality Standards (NAAQS) to protect public health. NAAQS were developed for six *criteria pollutants*: particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and lead (Pb). Particulate matter has two associated NAAQS: one for fine particulate matter less than 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$) and one for coarse particulate matter less than 10 micrometers in aerodynamic diameter (PM_{10}). Threshold limits established under the NAAQS to protect human health are known as primary standards. The primary health standards are to protect the most sensitive of the human population, including those people with existing respiratory or other chronic health conditions, children, and the elderly. Secondary standards established under the NAAQS are to protect the public welfare and the environment. Since promulgation of the original CAA, the EPA has continued to revise the NAAQS based on its assessment of national air quality trends and on current (and ongoing) health studies.

To protect public health and assess attainment with NAAQS, DEC established an air quality monitoring program. The State of Alaska has a large geographical area with a small population. Anchorage and the Matanuska-Susitna (Mat-Su) Valley have the bulk of the 710,231[1] people in the state, about 54%. The remainder of the population is distributed among the cities of Juneau and Fairbanks with populations of about 30,000-40,000 and many scattered and isolated small villages most of which are off the road system and have populations ranging from 16 people to 10,000 people. The total area of the state is approximately 1.7 million square kilometers (km) or 656,425 square miles[2].

[1] Population data obtained from the 2010 US Census, http://live.laborstats.alaska.gov/cen/dp.cfm
[2] Geographical data obtained from NetState.com, http://www.netstate.com/states/geography/ak_geography.htm

In accordance with the National Monitoring Strategy, DEC plans air monitoring activities using the following criteria:

- Monitor in larger communities to cover the largest possible population exposure;
- Monitor in designated smaller towns and villages that are representative of multiple communities in a region; and
- Monitor in response to air quality complaints.

The Air Monitoring & Quality Assurance (AMQA) program of the DEC Air Quality Division has a relatively small staff of professionals who conduct the state's air quality assessment efforts. To enhance the quality of work performed statewide DEC's staff works closely with the Municipality of Anchorage (MOA), the Fairbanks North Star Borough (FNSB), the Matanuska-Susitna Borough, the City & Borough of Juneau (CBJ) and environmental staff in other, smaller communities to assess air quality levels statewide. To continue to protect public health and the environment, air quality monitoring is focused on eight primary issues by descending priority:

1. Fine particulate matter ($PM_{2.5}$) monitoring
2. Coarse particulate matter (PM_{10}) monitoring
3. Wildland fire monitoring ($PM_{2.5}$)
4. PM Difference ($PM_{10-2.5}$) monitoring
5. Carbon monoxide (CO) monitoring
6. Rural communities and tribal village monitoring (primarily PM_{10})
7. Ozone (O_3) monitoring
8. Lead (Pb) monitoring

2.1 *Fine Particulate Matter - $PM_{2.5}$*

The primary sources of fine particulates in the atmosphere are emissions from combustion processes. Health research in the lower 48 states and Alaska has found that $PM_{2.5}$ size particles are creating major health problems throughout communities across the United States. For people in Alaska, this problem is exacerbated by increased exposure to fine particulate generated by home heating with wood during periods of extreme cold and extended wintertime temperature inversions which trap pollutants close to ground level. Smoke can also be a severe problem during spring and summer wildland fire season. Wildland fires may occur throughout Alaska but are very common to the central interior.

Wood smoke from home heating has been a major contributor to elevated fine particulate levels in Southeast Alaska for years. Juneau's Mendenhall Valley exceeded the PM_{10} standard numerous times in the late 1980s and early 1990s, but successfully reduced particulate matter levels with an effective wood smoke control program, public education, and woodstove conversion to pellet stoves and oil-fired space heaters.

Fine particulates have also been a concern in some Interior Alaska communities, especially during the winter months when extremely strong inversions trap emitted particles close to the surface. In the smaller, rural villages, this problem is normally associated with wood smoke. In the large communities like Fairbanks, which is designated as nonattainment for the 24-hour $PM_{2.5}$ NAAQS, the pollution is a mix primarily comprising wood smoke from woodstoves and hydronic heaters, but also including emissions from coal-fired power plants, vehicular traffic, and oil-fired heating systems.

2.2 *Coarse Particulates - PM_{10}*

PM_{10} or "dust" impacts are widespread throughout Alaska and have been a pollutant of concern for over 40 years. PM_{10} has been monitored in Anchorage, Juneau, the Mat-Su Valley, and Fairbanks for over twenty years. Two locations in the State were designated non-attainment for dust in 1991: the Municipality of Anchorage (Eagle River) and the City and Borough of Juneau (Juneau).

Dust has also been identified as a problem in most of the rural communities in Alaska. With the exception of the "hub" communities, most of the smaller villages have a limited road system and few resources with which to pave roads. In addition, the soil composition is often frost susceptible and not conducive to paving. With the recent addition of all-terrain vehicles (4-wheelers) and more automobiles and trucks, the amount of re-entrained dust has increased substantially.

2.3 *Carbon Monoxide-CO*

Alaska's two largest communities, Anchorage and Fairbanks were designated non-attainment for carbon monoxide (CO) in the mid to late 1980s. Motor vehicle CO emissions increase in the cold winter temperatures experienced in Alaska. These elevated emissions combined with strong wintertime temperature inversions resulted in both communities exceeding the CO standards numerous times each winter. Due to the implementation of control strategies such as public use of engine block heaters and improvement to vehicle ignition systems, neither community has had a violation of the CO standard in almost 15 years. Both communities requested re-designation to attainment and were reclassified as *maintenance* areas in 2004.

2.4 *Lead Monitoring-Pb*

To comply with the November 2008 revision of the state and federal air quality standard for lead, DEC explored establishing a source-oriented, lead monitoring site near the Red Dog Mine in Alaska's Northwest Arctic Borough. The Red Dog Mine, fifty miles inland, extracts lead and zinc ore from an open-pit mine and concentrates the ore at their processing facility for transport to the coast where it is stored for barging and eventual export. The intent of the revised lead standard was source-oriented monitoring for all facilities that had potential annual emissions equal to or greater than one half ton of lead. The Red Dog Mine is the state's only emission source that meets this criterion. The area around the mine is extremely remote, rugged terrain with no road access and no access to power. Initially a monitoring location was selected in the Native Village of Noatak, the closest community to the Red Dog Mine. EPA sanctioned the change in the monitoring strategy from source-oriented to population-oriented because of Alaska's rural character. The monitoring site was established in January 2010 and operated periodically through the middle of August 2011. The site consisted of collocated high volume samplers which collected samples for total suspend particulate (TSP). Filter analysis was performed at the Anchorage DEC Environmental Health laboratory. The site was finally shut down after DEC was unable to hire and maintain consistent local site operations using local residents. Several attempts to work through the tribe or by establishing private contracts were ultimately unsuccessful. Only two sampling periods yielded sufficient data to report to AQS, one from 1/13/2010 to 6/30/2010 and a second one from 6/6/2011 to 8/14/2011.

After consultation with EPA DEC decided to pursue a modeling demonstration to show that lead concentrations at the ambient boundary of the Red Dog Mine meet the new lead standard. For this alternative demonstration the modeled lead concentration outside the ambient air boundary have to be less than 50% of the NAAQS. Under 40 CFR 58, Appendix D, section 4.5 (ii) DEC submitted a modeling protocol as part of a waiver request to avoid the monitoring requirement on October 23, 2012. After initial review EPA requested updated information for the model's emissions inputs. EPA, DEC and Red Dog Mine cooperatively set a schedule for submission of the updated information. Additional soil sampling was required to adequately determine emission factors for the gravel roads. Due to weather and road conditions the soil sampling was not completed until late May 2014. Laboratory analysis of the samples and development of new emission factors is scheduled to be completed by late July. DEC and EPA requested a minimum of 30 days for review and approval. Once EPA approves the new emissions inventory, DEC plans to rerun the modeling and anticipates to generate a final report within six months. Should the modeling show that lead levels around the mine ambient boundary exceed 50% of the lead standard, the Red Dog Mine will be required to start a monitoring program. At that point DEC will work with the mine to select a site and develop a schedule for the start-up of the monitoring project.

2.5 *Ozone Monitoring-O_3*

The March 27, 2008 revision of the national ozone standard required the State of Alaska to establish an O_3 monitoring program by April 1, 2010. The regulation required at least one State and Local Air Monitoring (SLAMS) O_3 site in a core based statistical area (CBSA) with a population greater than 350,000. The Anchorage/Mat-Su Valley population forms the only combined Metropolitan Statistical Area (MSA) in the State of Alaska which meets the criterion. The MOA Garden site was selected as a metropolitan site. Monitoring was conducted during O_3 season from 2010 through 2012. An O_3 monitoring site was also established in Wasilla in May 2011. The multi-pollutant NCORE site in Fairbanks began monitoring for O_3 in 2012.

2.6 *Sulfur Dioxide Monitoring-SO_2*

The State of Alaska currently has no MSA which would require SO_2 monitoring under 40 CFR 58, Appendix D, paragraph 4.4.2. The only continuous SO_2 monitoring currently being performed in Alaska is at the NCORE site in Fairbanks. Monitoring for SO_2 was performed in Southeast Alaska in the 1980s and early 1990s in response to public concerns about emissions from the two regional pulp mills. While elevated concentrations were observed during the monitoring, the 8-hour SO_2 standard at the time was not exceeded. With the revision of the SO_2 standard and introduction of the 1-hour standard, additional monitoring in rural communities may be warranted. Short term studies in St. Mary's and Fairbanks indicate a potential for exceedances of the SO_2 standard during the winter time. Especially in light of the ubiquity of diesel power generation in rural Alaska, elevated SO_2 levels might be a widespread issue. A short-term monitoring program was conducted in the City of Eagle Alaska during the winter of 2013-14 due to public health concerns related to emissions from an underground shale-oil fire. No elevated concentrations were observed. As staffing and funding allows, DEC will conduct studies in rural communities to better understand the issue.

2.7 *Nitrogen Oxides Monitoring-NO_2 and NO_y*

Nitrogen oxides are a group of air pollutant compounds that primarily form during combustion and then react photo-chemically in the atmosphere to form secondary pollutants. This group of pollutants were consolidated and are regulated as a single pollutant under the NAAQS as nitrogen dioxide (NO_2). The State of Alaska currently has no MSA which would require NO_2 monitoring under 40 CFR 58, Appendix D, paragraph 4.3. Historically NO_2 monitoring was conducted as part of the Unocal Tesoro Air Monitoring Program (UTAMP) conducted in North Kenai during the early 1990s. The state operated its own independent monitoring site and measured for ammonia and NO_2. Elevated short term NO_2 values were observed, but the annual concentration was not exceeded.

With the revision to the NO_2 standard and introduction of the 1- hour NO_2 standard, DEC will have to evaluate if, and where, additional monitoring will be warranted.

As part of the multi-pollutant monitoring program and in an effort to better understand atmospheric chemistry in a non-attainment area, total reactive nitrogen compounds (NO_y) and ammonia (NH_3) monitors were installed at the NCORE site in Fairbanks. Unfortunately, due to instrument response-time and other technical instrumentation issues, the NH_3 monitoring program failed and the monitor was taken out of service. The instrument was replaced with a NO_X/NO/NO_2 trace-level monitor in February 2014.

3 State of Alaska Ambient Air Monitoring Network

3.1 *Monitoring Sites*

DEC operates and maintains a number of ambient air monitoring networks throughout the State of Alaska and provides technical support and oversight for air monitoring sites operated by the local air quality agencies in the Municipality of Anchorage and the Fairbanks North Star Borough. Table 3-1 provides the site name, address, geographic coordinates, and identification number for all the air monitoring sites submitting data to the EPA Air Quality System (AQS) data base as of July 1, 2014.

Table 3-1 AQS Monitoring Site as of July 1, 2014

Site Name	Address	Latitude/ Longitude*	AQS Identification
Garden Site	Municipality of Anchorage Trinity Christian Church 3000 East 16th Ave. Anchorage, AK	61.205861N -149.824602W	02-020-0018
Tudor Road Site	Municipality of Anchorage 3335 East Tudor Rd Anchorage, AK	61.181083N -149.817389W	02-020-0044
Turnagain Site	Municipality of Anchorage Unitarian Church 3201 Turnagain St. Anchorage, AK	61.191514N -149.934930W	02-020-0048
Parkgate/Eagle River Site	Municipality of Anchorage 11723 Old Glenn Hwy. Eagle River, AK	61.326700N -149.569707W	02-020-1004
Old Post Office Site	Fairbanks North Star Borough 250 Cushman St. Fairbanks, AK	64.845278N -147.721111W	02-090-0002
State Office Building Site	Fairbanks North Star Borough Federal Building 675 Seventh Ave. Fairbanks, AK	64.840833N -147.723056W	02-090-0010
NCORE Site	Fairbanks North Star Borough 809 Pioneer Road Fairbanks, AK	64.845307N -147.72552W	02-090-0034

North Pole Fire Station #3 Site	Fairbanks North Star Borough 388 Hurst Rd. North Pole, AK	64.762973N -147.310297W	02-090-0035
Butte Site	Matanuska-Susitna Valley Harrison Court Butte, AK	61.534100N – 149.0351855W	02-170-0008
Palmer Site	Matanuska-Susitna Valley South Gulkana St. Palmer, AK	61.599322N -149.103611W	02-170-0012
Wasilla Site	Matanuska-Susitna Valley 100 West Swanson Wasilla, AK	61.583331N -149.453624W	02-170-0013
Floyd Dryden Middle School Site	City and Borough Juneau 3800 Mendenhall Loop Road Juneau, AK	58.388889N -134.565556W	02-110-0004
Kenai Peninsula Borough Building Site	Kenai Peninsula Borough 144 North Binkley St. Soldotna, AK	60.489131N –151.070017W	02-122-0008

* Coordinates for latitude and longitude are consistent with the World Geodetic System (WGS 84).

Figure 3-1 shows the State of Alaska air monitoring networks that report to the EPA AQS data base. Regional maps showing the monitoring networks for the Municipality of Anchorage, Fairbanks North Star Borough, Matanuska-Susitna Valley, City and Borough of Juneau, and Kenai Peninsula Borough are presented in Figures 3-2 through 3-6. In addition to the network maps, area maps are presented which provide greater detail of the individual site locations. All map base images were prepared using Google Earth® with Landsat and US Geological Survey digital images.

In 2014 EPA Region 10 provided network evaluation forms to determine compliance with design and minimum monitoring requirements for each of the criteria pollutants under 40 CFR 58, Appendix D. These site evaluation forms were completed by DEC and are presented for review in **Appendix A** of this report.

Figure 3-1 State of Alaska AQS Air Monitoring Networks

Figure 3-2 Municipality of Anchorage Air Monitoring Network

Figure 3-2a Municipal of Anchorage Garden Site Area Map (Neighborhood Scale Site)

Figure 3-2b Municipality of Anchorage Tudor Road Site Area Map (Micro-Scale Site)

Figure 3-2c Municipality of Anchorage Turnagain Heights Area Map (Neighborhood Scale Site)

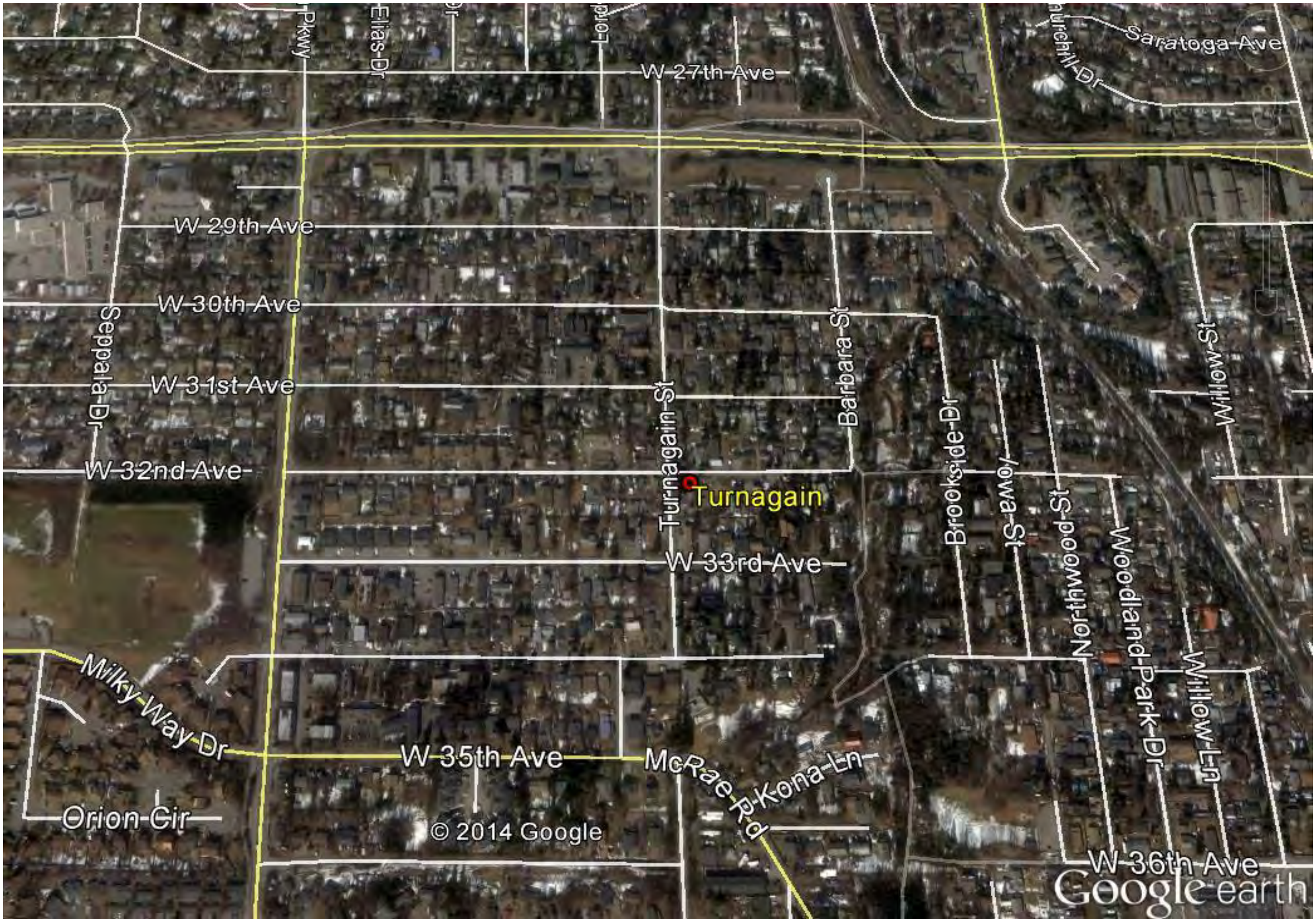

Figure 3-2d Municipality of Anchorage, Parkgate Eagle River Area Map (Neighborhood Scale Site)

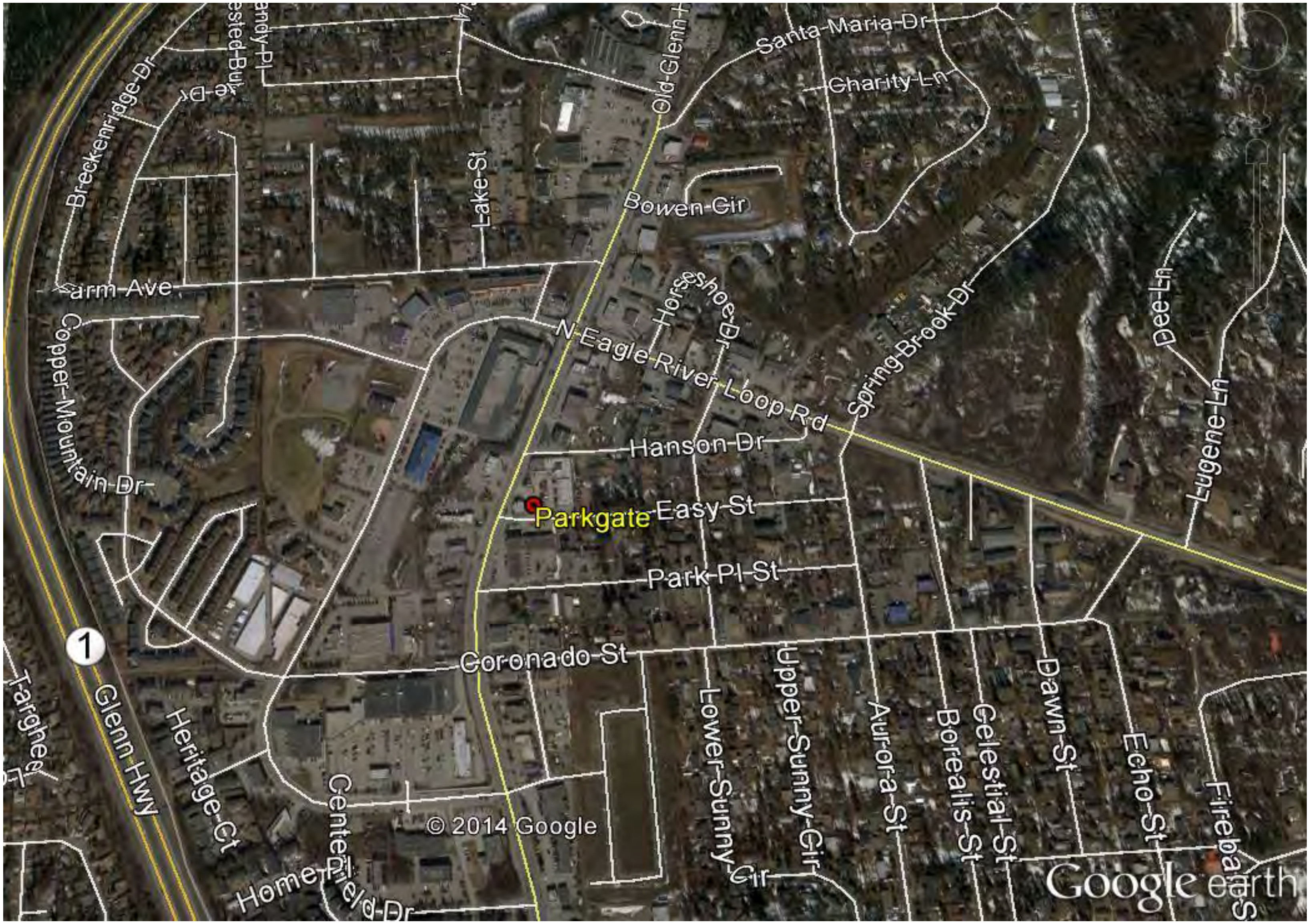

Figure 3-3 Fairbanks North Star Borough Air Monitoring Network

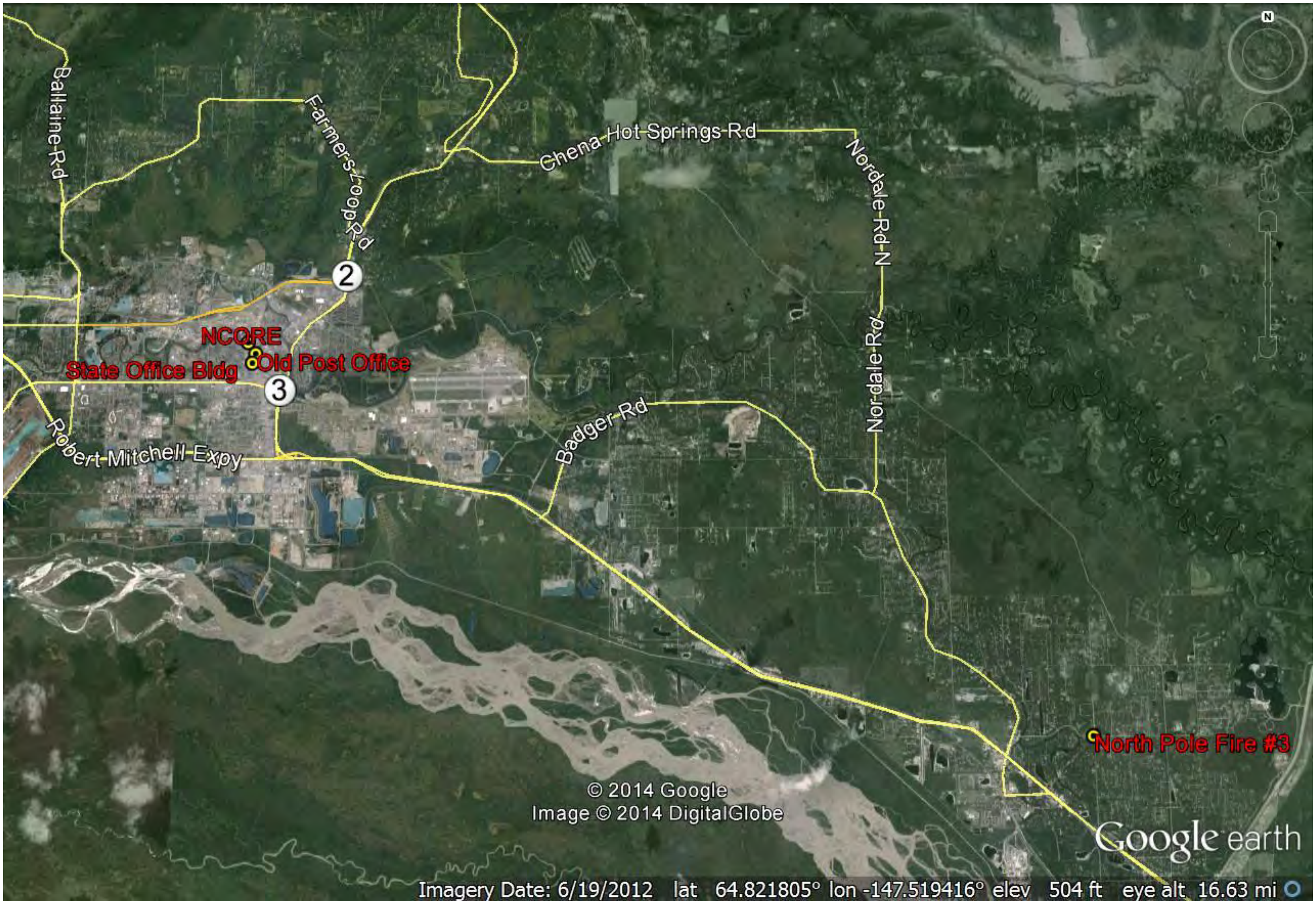

Figure 3-3a Fairbanks Downtown Area Map for the NCORE Site, the Old Post Office (Micro-Scale Site), and the State Office Building (Neighborhood Scale Site)

Figure 3-3b North Pole Fire #3 Area Map (Micro-Scale Site)

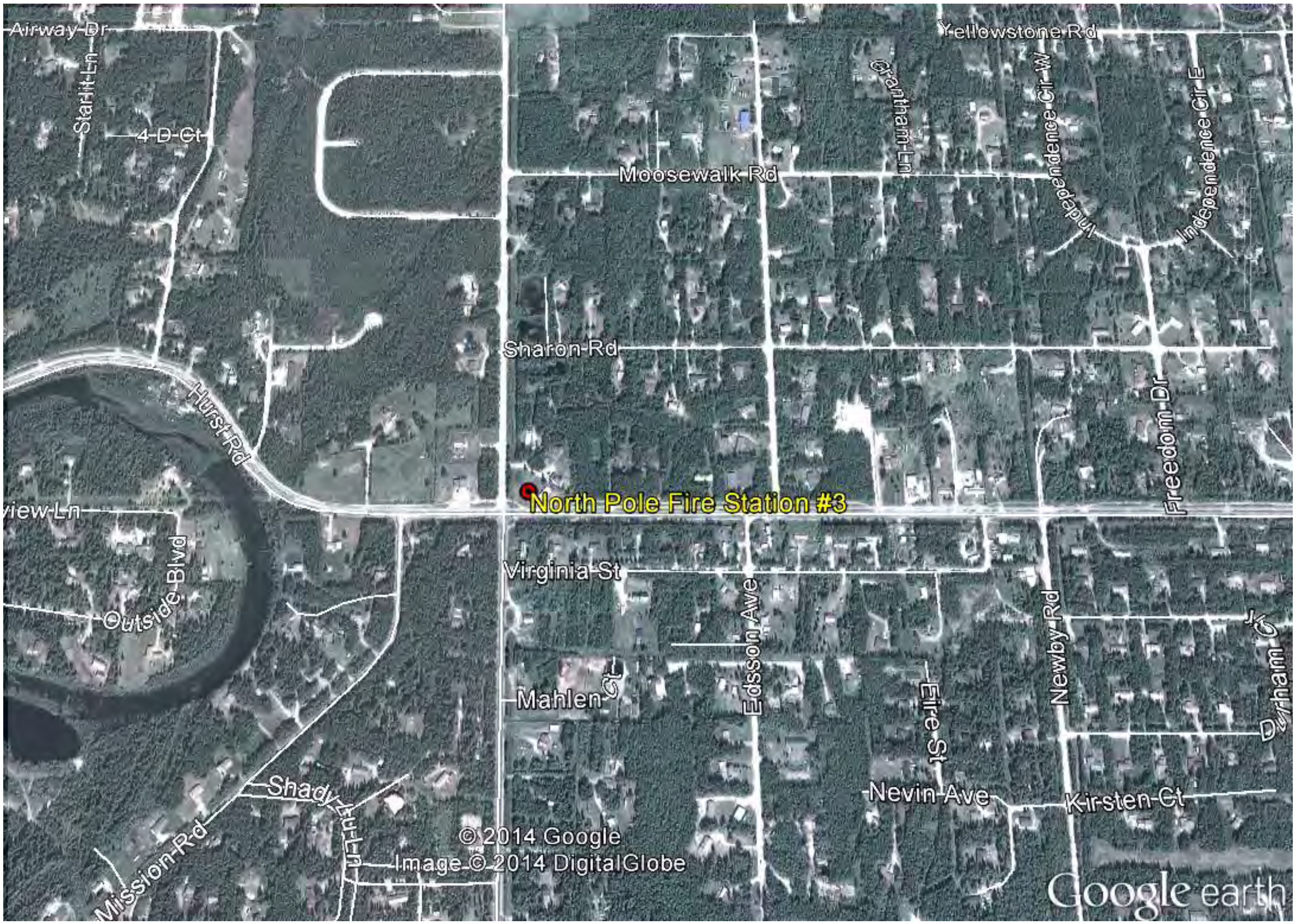

Figure 3-4 Matanuska-Susitna Valley Air Monitoring Network

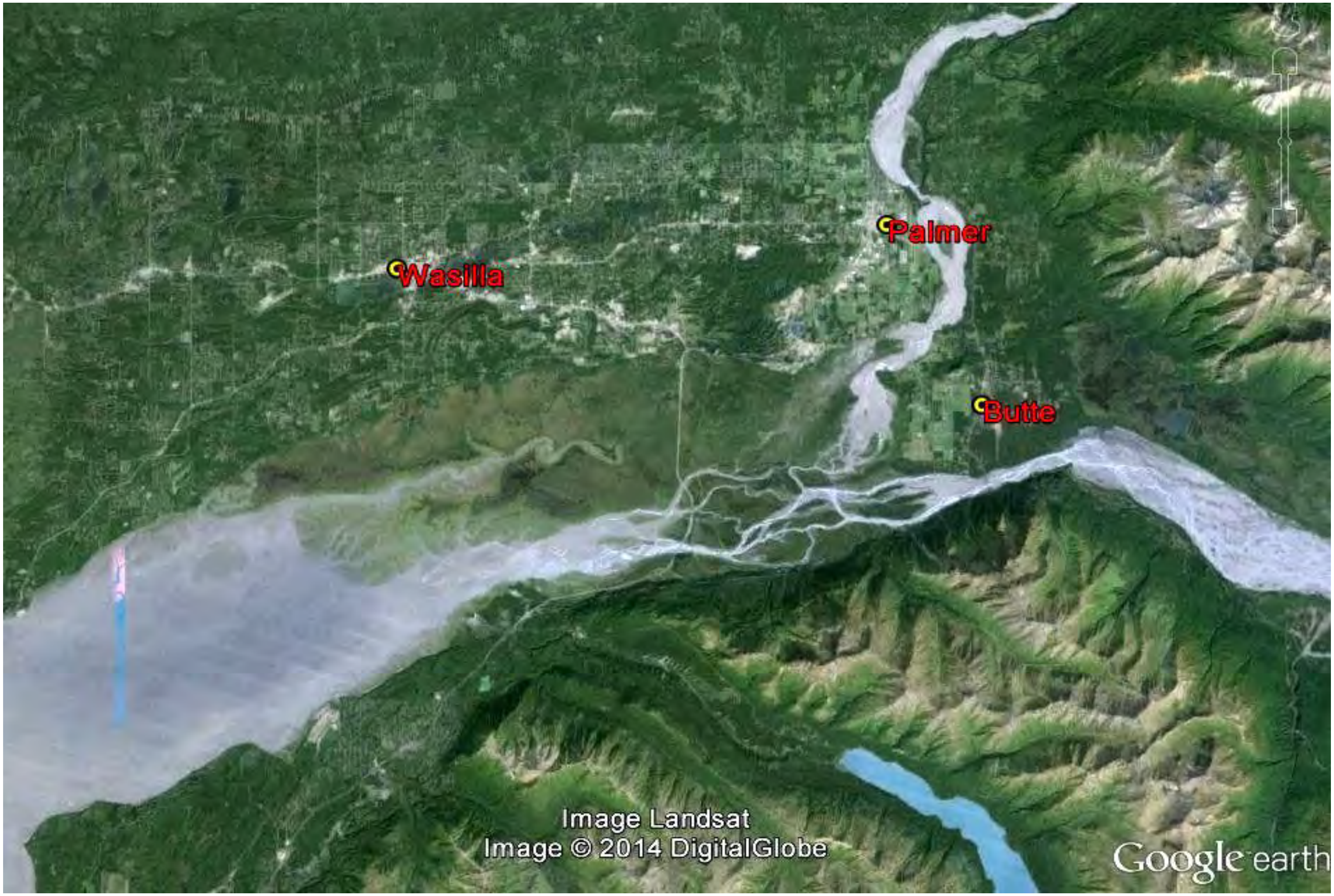

Figure 3-4a Matanuska-Susitna Valley, Butte Area Map (Neighborhood Scale Site)

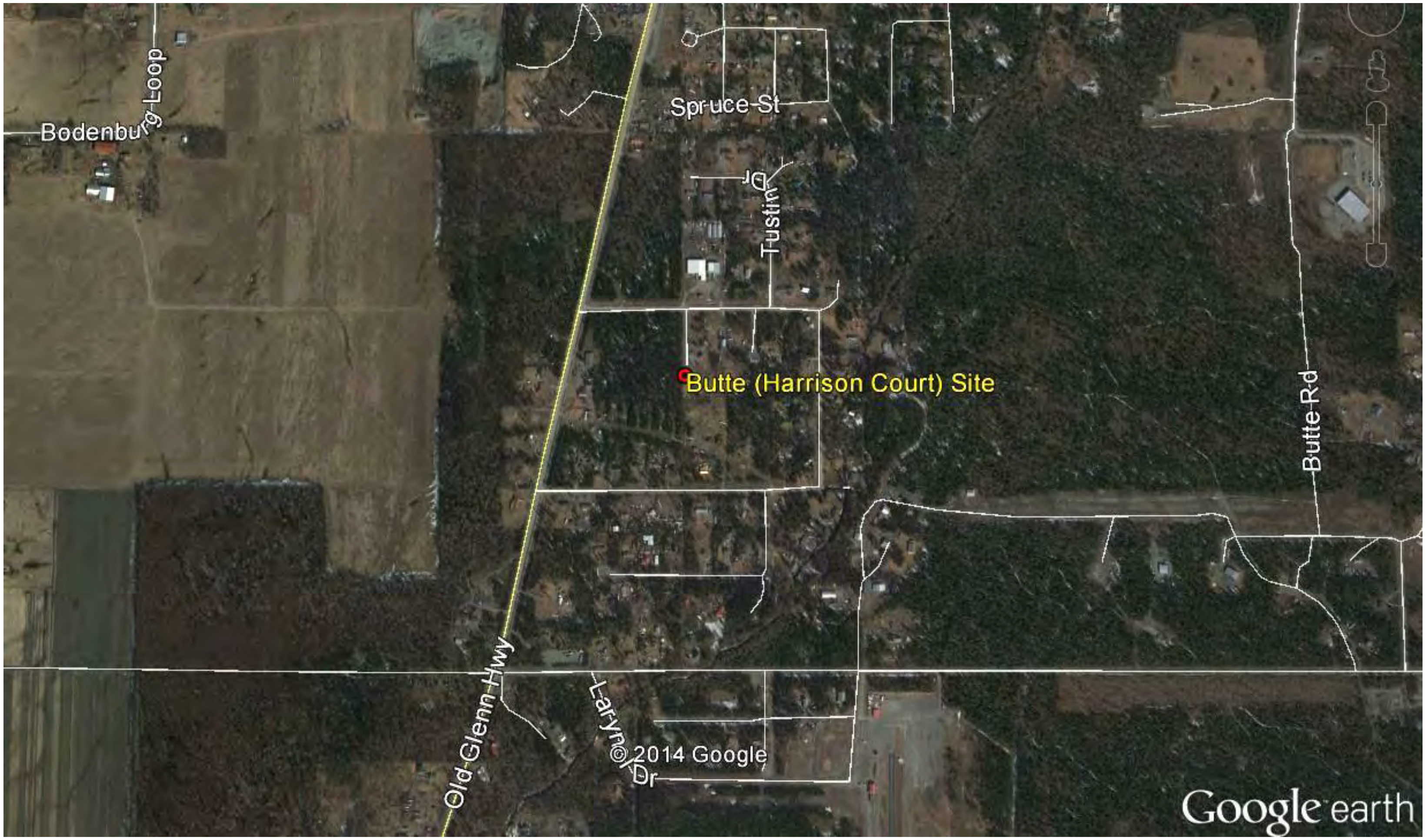

Figure 3-4b Matanuska-Susitna Valley, Palmer Area Map (Neighborhood Scale Site)

Figure 3-4c Matanuska-Susitna Valley, Wasilla Area Map (Neighborhood Scale Site)

Figure 3-5 City and Borough of Juneau Air Monitoring Network (single site)

Figure 3-5a Floyd Dryden Middle School, Mendenhall Valley Area Map (Neighborhood Scale Site)

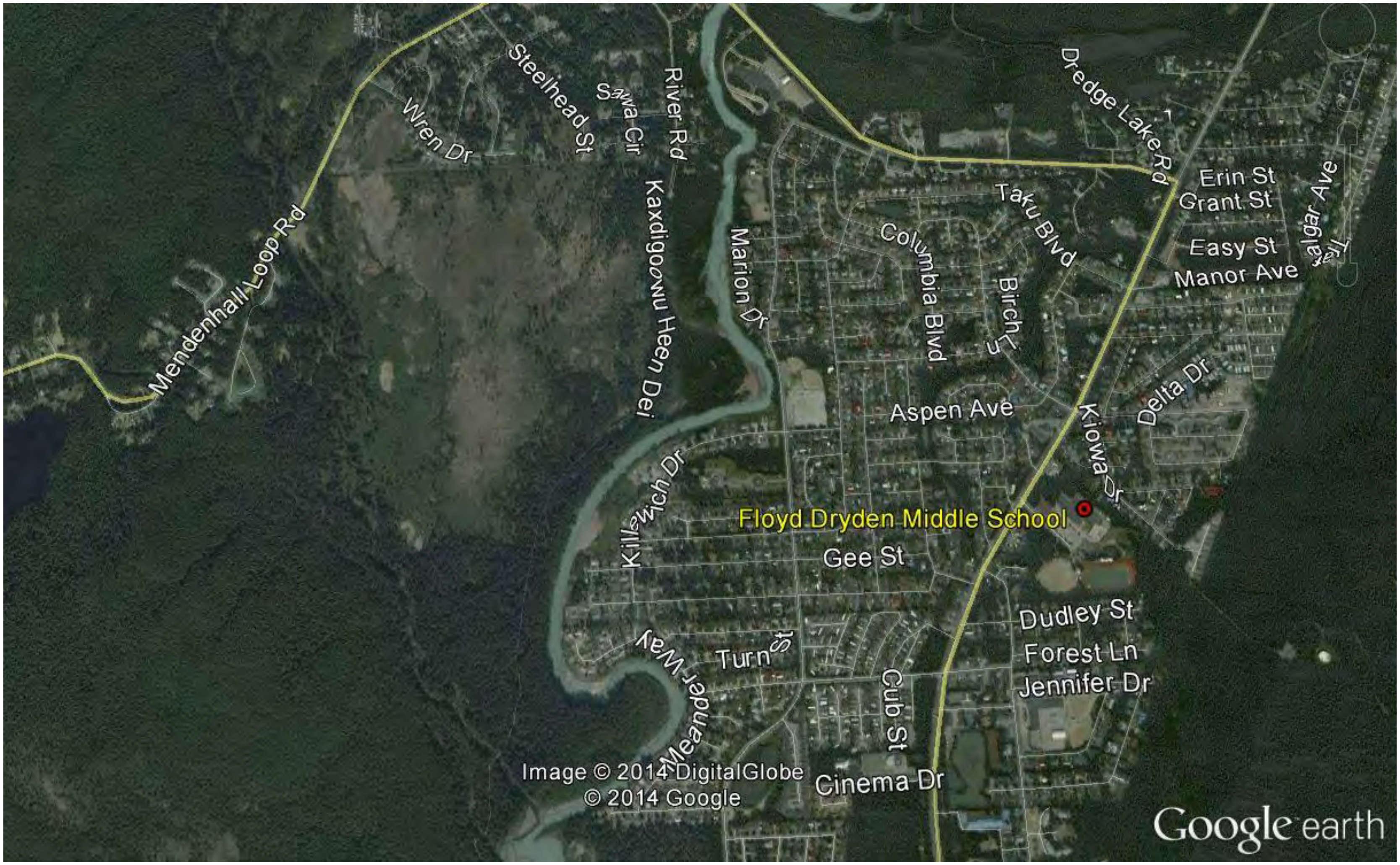

Figure 3-6 Kenai Peninsula Borough Air Monitoring Network (single site)

Figure 3-6a Kenai Peninsula Borough, Soldotna Area Map (Neighborhood Scale Site)

3.2 *Siting Criteria*

In 2014 EPA Region 10 also provided site evaluation forms to determine compliance with 40 CFR 58 (Appendix E) requirements for monitoring path and siting criteria. These forms were distributed to the individual site operators for completion. Those site evaluation forms are presented in **Appendix B** of this report. Included are two tables: one for CO sites (Table 3-2) and one for PM sites (Table 3-3). Certain sites have been found to have had their monitoring scale incorrectly designated. A discussion of the monitoring scale changes follows each table.

Carbon Monoxide Sites

Carbon monoxide (CO) inlet probes should be at least 1 meter away, both vertically and horizontally, from any supporting structure or wall. For micro-scale sites the probe height must be between 2.5 and 3.5 meters, whereas for other scale sites the probe must be between 3 and 15 meters high.

A probe must have unrestricted airflow for at least 270 degrees, or 180 degrees if it is located on the side of a building. Obstructions must be a minimum distance away equal to twice the distance by which the height of the obstruction exceeds the height of the probe. Trees should not be present between the dominant CO source or roadway and the inlet probe.

The following is a list with definitions on monitoring site scaling;

Micro-scale—defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.

Middle Scale—defines the concentration typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer.

Neighborhood Scale—defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range.

Urban Scale—defines the overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale would usually require more than one site for definition.

The following table (Table 3-2) lists all CO monitoring sites in Anchorage and Fairbanks (including SPM) and how they fit the siting criteria from Appendix E of 40 CFR Part 58.

Table 3-2 CO Monitoring Sites in Anchorage and Fairbanks July 2013-June 2014.

Site Name	Monitoring Scale	Probe Distance from Wall (meters)	Height (meters)	Unrestricted Air Flow	Spacing from Roadway (meters)	Trees
Garden	Neighborhood	1	3	180 degrees unobstructed	7	Yes
Turnagain	Neighborhood	1	3	180 degrees unobstructed	12 from 500 VPD roadway	Yes
NCORE	Neighborhood	Not applicable	4	360 degrees unobstructed	85	None
Old Post Office	Micro-scale	1	3	180 degrees unobstructed	3	None

Particulate Matter (PM_{10} and $PM_{2.5}$) Sites

For micro-scale sites particulate matter inlets must be between 2 and 7 meters from ground level. For other siting scales the probe must be between 2 and 15 meters high.

A sampler must have at least 2 meters separation from walls, parapets, penthouses, etc. A sampler must have unrestricted airflow for at least 270 degrees, or 180 degrees for street canyon sites. Obstructions must be a minimum distance away from the sampler with the separation equal to twice the distance by which the height of the obstruction exceeds the height of the sampler inlet.

Micro-scale sampler inlets must be located between 5 and 15 meters from the nearest traffic lane for traffic corridor sites, and between 2 and 10 meters for street canyon sites. The minimum separation distance between the probe and nearest traffic lane for middle, neighborhood, or urban scale sites depends upon the number of vehicles per day (VPD) that use the roadway according to a rather complicated table in Appendix E of 40 CFR Part 58. Table 3-3 lists all PM monitoring sites in Alaska (including SPM) and how they fit the siting criteria from Appendix E of 40 CFR Part 58.

Table 3-3: PM Monitoring Sites in Alaska as of July 1, 2014

Site Name	Monitoring Scale	Height (meters)	Spacing from Obstructions (meters)	Spacing from Roadway (meters)	Traffic (VPD)	Trees
Garden	Neighborhood	10	12m to 5m tall penthouse	10	< 5,000	None
Tudor	Micro-scale	3.3	4m, tree tops level with inlet	7	46,900	3 trees to the south
Parkgate	Neighborhood	6	13m to 4m tall penthouse	44	11,000	None
Harrison Court	Neighborhood	4	> 8	150	Unknown, probably < 5,000	None
Palmer	Neighborhood	4	> 8	18	Unknown, probably < 5,000	None
Wasilla	Neighborhood	4	> 8	20	16,494	None
State Office Building	Neighborhood	6	30m to 3.75m tall penthouse	20	7,400	None
NCORE	Neighborhood	4	75 m to 12 m building	85	3,559	None
North Pole Fire #3	Micro-scale	4	none	23 to Hurst Rd	3,730	> 30
Floyd Dryden	Neighborhood	6	Furnace flue @ 20m, 4m penthouse @ 15m	65	12,770	12 m tall 25m away
Soldotna	Neighborhood	4	None	~ 30	< 5,320	10 m to group of 6 m tall trees

3.3 *Monitoring Methods, Designation and Sampling Frequency*

Table 3-4 presents information used in coding the data submitted by DEC to the AQS database. The information provided in Table 3-4 for each monitoring site includes pollutant parameter name, monitor designation, the AQS parameter and POC codes, the AQS method code, the frequency of sampling, and the instrumentation used. The monitor designation states the purpose for which the data are to be used, such as: for State & Local Air Monitoring (SLAM) to demonstrate NAAQS compliance, Special Purpose Monitoring (SPM) for general air quality assessments, and the Chemical Speciation Network (CSN) for atmospheric chemistry assessments. The 5-digit AQS parameter codes are specific to the pollutant, instrumentation or sampling equipment used, and how the concentration units are expressed in either local conditions or corrected to standard conditions for temperature and pressure. The 5-digit parameter code identifies the parameter being measured e.g. PM_{10}, SO_2, or wind speed. The 1-digit POC code is the parameter occurrence code. The POC indicates whether the sampler or instrument is a primary data source (1) or a secondary data source such as a collocated sampler (2) or that an instrument is measuring on a continuous basis (3). The AQS method code provides information specific to the analytical technique used for the pollutant determination such as instrumental analysis using chemiluminescence for nitric oxide or gravimetric analysis for particulate. The notation presented in the sample frequency indicates how often the pollutant concentration is determined. For example, 1/6 indicates that one sample is collected every sixth day according to the national EPA air monitoring schedule. Continuous indicates that an instrument is continuously analyzing a sample stream providing a pollutant concentration on a real-time basis (e.g. 1-min SO_2 reading) or a near-real time basis (e.g. 1-hour $PM_{2.5}$ reading from a beta attenuation monitor, a BAM). The equipment information column identifies specific on-site equipment (either a sampler or instrument) to the AQS parameter code.

Other monitoring sites operated by DEC to gather data related to rural road dust and wildland fires, but that are not submitted to the AQS data base are discussed in **Appendix C**. The IMPROVE monitoring sites operated in Alaska under the federal program to characterize and protect scenic visibility around National Parks and designated wilderness areas are described in **Appendix D**.

A summary of pollutant concentration data calculated as NAAQS design values are presented in **Appendix E**.

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Table 3-4 Air Monitoring Method Codes July 1, 2014

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
Garden Site Anchorage	PM_{10STD}	SLAM	01/01/2009	81102-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SLAM	01/01/2009	88101-3	170	Continuous	Met-One BAM 1020X Coarse
	CO	SLAM	01/01/1979	42101-1	554	Continuous Seasonal Oct-Mar	Thermo Env. Inst. Model 48i
Turnagain Anchorage	CO	SLAM	10/15/1998	42101-1	054	Continuous Seasonal Oct-Mar	Thermo Env. Inst Model 48c
Tudor Anchorage	PM_{10STD}	SLAM	07/01/2010	81102-3	122	Continuous	Met-One BAM 1020X Coarse
Parkgate Eagle River	$PM_{2.5LC}$	SLAM	01/01/2009	88101-3	170	Continuous	Met-One BAM 1020X Coarse
	PM_{10STD}	SLAM	01/01/2009	81102-3	122	Continuous	Met-One BAM 1020X Coarse
State Office Building	$PM_{2.5LC}$ Carbon	CSN	03/17/2005	Multiple*	Multiple*	1/3	URG 3000N

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
Fairbanks	$PM_{2.5LC}$ Speciation	CSN	03/17/2005	Multiple*	Multiple*	1/3	Met-One Super-SASS
	$PM_{2.5LC}$	SLAMS	10/23/1998	88101-1	117	1/3	R & P Partisol 2000
Old Post Office Fairbanks	CO	SLAM	10/01/2009	42101-1	054	Continuous Seasonal Oct-Mar	Thermo Env. Inst. Model 48c
NCORE Fairbanks	PM_{10LC}	NCORE	02/15/2011	85101-3	122	Continuous	Met-One BAM 1020X Coarse
	PM_{10STD}	NCORE	02/15/2011	81102-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	NCORE	02/15/2011	88501-3	170	Continuous	Met-One BAM 1020X Coarse
	PM_{10LC} - $PM_{2.5LC}$	NCORE	02/15/2011	86101-3	185	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	NCORE	11/04/2009	88101-1	117	1/3	R&P Partisol 2000
	$PM_{2.5LC}$ collocated	NCORE	05/01/2013	88101-2	117	1/6	R & P Partisol 2000
	PM_{10STD}	NCORE	11/10/2012	81102-1	126	1/3	R&P Partisol 2000
	PM_{10LC}	NCORE	11/10/2012	85101-1	126	1/3	R&P Partisol 2000

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
NCORE Fairbanks	CO	NCORE	08/01/2011	42101-1	554	Continuous	Thermo Fisher 48i
	SO_2 (1-hr)	NCORE	08/01/2011	42401-1	560	Continuous	Thermo Fisher 43i-TL
	SO_2 (5-min)	NCORE	08/18/2011	42401-2	560	Continuous	Thermo Fisher 43i-TL
	NO_Y	NCORE	10/05/2012	42600-1	574	Continuous	Thermo Fisher 42iY-TL
	NO	NCORE	10/05/2012	42601-1	574	Continuous	Thermo Fisher 42iY-TL
	$PM_{2.5LC}$ Speciation	CSN**	Not Submitted to AQS	Multiple*	Multiple*	1/3 Seasonal Nov-Mar	Met-One Super-SASS
	NO_X	NCORE	03/01/2014	42603-1	074	Continuous	Thermo Fisher 42i-TLi
	NO	NCORE	03/01/2014	42601-1	074	Continuous	Thermo Fisher 42i-TL
	NO_2	NCORE	03/01/2014	42602-1	074	Continuous	Thermo Fisher 42i-TL

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
NCORE Fairbanks	O_3	NCORE	08/01/2011	44201-1	087	Continuous	Teledyne API 400E
	WD	NCORE	04/05/2011	61104-1	061	Continuous	Met-One Sonic Anemometer
	WS	NCORE	04/05/2011	61103-1	061	Continuous	Met-One Sonic Anemometer
	BP	NCORE	04/05/2011	64101-1	014	Continuous	Met-One Barometer
	Amb Tmp 2 m	NCORE	04/01/2011	62101-2	061	Continuous	Met-One
	Amb Tmp 10 m	NCORE	04/01/2011	62101-1	061	Continuous	Met-One
	$PM_{2.5LC}$	SPM	Not Submitted to AQS	NA**	NA**	1/3 Seasonal Oct-Mar	Met-One Super SASS $PM_{2.5}$ LC
North Pole Fire #3	$PM_{2.5LC}$	SPM	03/014/2012	88101-1	117	1/3 Seasonal Oct - Mar	R&P Partisol 2000
	$PM_{2.5LC}$	SPM	Not Submitted to AQS	88501-3	170	Continuous	Met-One BAM 1020X Coarse
	PM_{10STD}	SPM	Not Submitted to AQS	81102-3	122	Continuous	Met-One BAM 1020X Coarse

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
Palmer Mat-Su Valley	PM_{10LC}	SPM	01/01/2010	85101-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SPM	01/01/2010	88101-3	170	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SPM	10/05/2012	88101-1	117	1/6	R&P Partisol 2000
	PM_{10STD}	SPM	01/01/2010	81102-3	122	Continuous	Met-One BAM 1020X Coarse
Butte Mat-Su Valley	PM_{10LC}	SPM	04/11/1998	85101-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SLAM	08/10/2011	88101-3	170	Continuous	Met-One BAM 1020X Coarse
	PM_{10STD}	SPM	04/11/1998	81102-1	126	1/6	R&P Partisol 2000
	PM_{10LC}	SPM	04/11/1998	85101-1	126	1/6	R&P Partisol 2000
	$PM_{2.5LC}$	SPM	04/11/1998	88101-1	117	1/6	R&P Partisol 2000

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
Butte Mat-Su Valley	PM_{10STD}	SPM	08/10/2011	81102-3	122	Continuous	Met-One BAM 1020X Coarse
Wasilla Mat-Su Valley	PM_{10LC}	SPM	10/01/2008	85101-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SPM	10/01/2008	88101-3	170	Continuous	Met-One BAM 1020X Coarse
	O_3	SPM	04/15/2011	44201-1	087	Continuous Seasonal Apr - Oct	Teledyne API 400E
Floyd Dryden Middle School Juneau	PM_{10STD}	SLAM	01/01/1986	81102-1	126	1/6	R&P Partisol 2000
	PM_{10STD}	SLAM collocated	01/01/1986	81102-2	126	1/6	R&P Partisol 2000
	PM_{10LC}	SPM	01/01/1986	85101-1	126	1/6	R&P Partisol 2000
	PM_{10LC}	SPM collocated	01/01/1986	85101-2	126	1/6	R&P Partisol 2000

Site Name/ Location	Pollutant Parameter	Monitor Designation	Monitoring Starting Date	AQS Parameter Code - POC Code	AQS Method Codes	Sample Frequency	Equipment Information
Floyd Dryden Middle School Juneau	$PM_{2.5LC}$	SLAM	08/21/2009	88101-3	170	Continuous	Met-One BAM 1020X Coarse
Kenai Peninsula Borough Building Soldotna	PM_{10STD}	SPM	10/20/2011	81102-3	122	Continuous	Met-One BAM 1020X Coarse
	PM_{10LC}	SPM	10/20/2011	85101-3	122	Continuous	Met-One BAM 1020X Coarse
	$PM_{2.5LC}$	SPM	10/20/2011	88101-3	170	Continuous	Met-One BAM 1020X Coarse

* - multiple AQS codes are used to identify individual chemical species.
** - the NCORE $PM_{2.5LC}$ speciation monitoring program will be discontinued in July 2014.

4 PROPOSED NETWORK MODIFICATIONS FOR 2014 - 2015

4.1 *$PM_{2.5}$ Network*

4.1.1 Fairbanks Speciation

DEC proposes relocating the CSN site to the NCORE site by October 1, 2014. The NCORE site is located less than 0.5 miles from the State Office Building (SOB) site and was intended to include the CSN site. The Fairbanks North Star Borough installed a Met One Super SASS $PM_{2.5}$ speciation monitor at the NCore site in the fall of 2011. Up until now, DEC paid for the analysis with Federal Highway Administration (FHWA) CMAQ funds. DEC contracted RTI to perform the laboratory analysis because RTI is the laboratory with which EPA contracted to analyze the filters from all the national CSN sites, including the SOB CSN site. Due to changes in FHWA grant eligibility, monitoring projects like the speciation sampling at the NCore and SOB sites no longer qualify for CMAQ funding. DEC does not have any additional funding source to maintain sampling at both sites and suggests relocating the official CSN site from the SOB to the NCore site. The NCore speciation sampling funded through the CMAQ grant will end July 2014.

A comparison of the 2011/2012 and 2012/2013 winter speciation data shows very good agreement between both sites. Although filters were also collected and analyzed during the summer of 2012, the summertime $PM_{2.5}$ concentrations are so low that they make a comparison difficult and, thus, the summer data were not included in the following analysis.

The correlations presented below compare the major components of $PM_{2.5}$ ($PM_{2.5}$ mass, Organic Carbon, Elemental Carbon, Total Carbon, Sulfate, Nitrate and Ammonium) for all filters for winter only from November 2011 through March 2013 between the SOB and NCore sites. Both sites collected samples every third day. For the two winters 101 filter samples were compared. The correlated data are displayed in Figures 4-1 and 4-2. The total $PM_{2.5}$ mass as measured by the speciation samplers is compared in Figure 4-1.

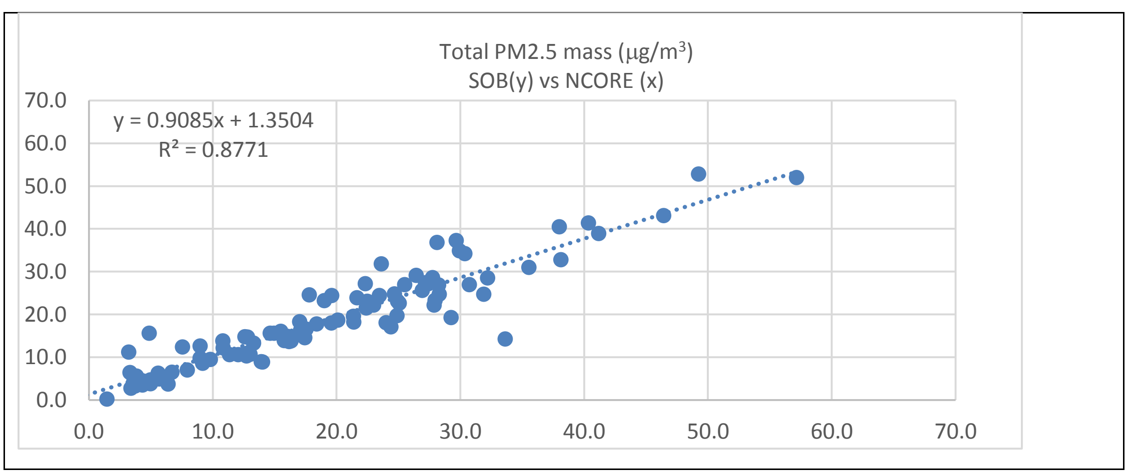


Figure 4-1 Correlation of NCore and SOB PM2.5 mass (species) from two winter seasons, 2011/12 and 2012/13

$PM_{2.5}$ mass correlates well. Figure 4-2 shows the correlation of the other $PM_{2.5}$ species. A simple side by side comparison of the carbon analysis is expected to show some discrepancies, since the NCore site did not have the same sampler as was used at the CSN site at the SOB. Never the less all the compounds show good correlation, with r^2 values above 0.82 for all above mentioned compounds except elemental carbon (EC).

The EC plot below shows a number of days for which the NCore EC mass concentration is almost double the SOB EC mass. Elemental carbon usually makes up less than 10% of the overall $PM_{2.5}$ mass. Part of the discrepancy of the EC correlation is that two different analysis methods are used for carbon. The SOB CSN site is equipped with the EPA required carbon sampler (URG-3000N) using the IMPROVE –TOR (Interagency Monitoring of Protected Visual Environments- Thermal Optical Reflective) EPA preferred method and the NCore site used the NIOSH (National Institute for Occupational Safety and Health) developed method. It is possible to apply correlations to EC measurements, but then a mass balance approach is used to derive Organic Carbon with the SANDWICH (Frank, 2006) method. The SANDWICH method is used for comparing FRM $PM_{2.5}$ mass concentrations verses speciation total $PM_{2.5}$ mass concentrations, not for comparing two speciation sites. To directly compare two speciation measurements it is best to compare the Total Organic Carbon (TOC). The two TOC concentrations that are reported to AQS for the SOB and NCore sites use the above mentioned different analysis methods. To better assess the relationships between the SOB and NCore, as well as other speciation sites within the non-attainment area an additional filter was collected at the SOB during the winter of 2011 through the winter of 2012/13. These filters were analyzed according to the same NIOSH method as used for the NCore site.

A direct comparison the Total Organic Carbon NIOSH method results from both sites is shown in the bottom graph of Figure 4.2. The correlation has an r^2 value of 0.84 and percent difference of 4%. Even collocation at one site would be considered well within the allowable criteria with an overall percent difference below 4%, let alone comparing two separate locations. Figure 4.2 also shows EC collocated at the State Office Building (EC-NIOSH and EC IMPROVE-TOR corrected to NIOSH). Differences exist even when measuring EC at the same site, see the correlation coefficient of r2 = 0.56. DEC is not able to determine if the remaining discrepancy between these measurements is a reflection of different source mixes at the two sites, laboratory analysis errors, other measurement issues, or a combination of all of the above listed possibilities.

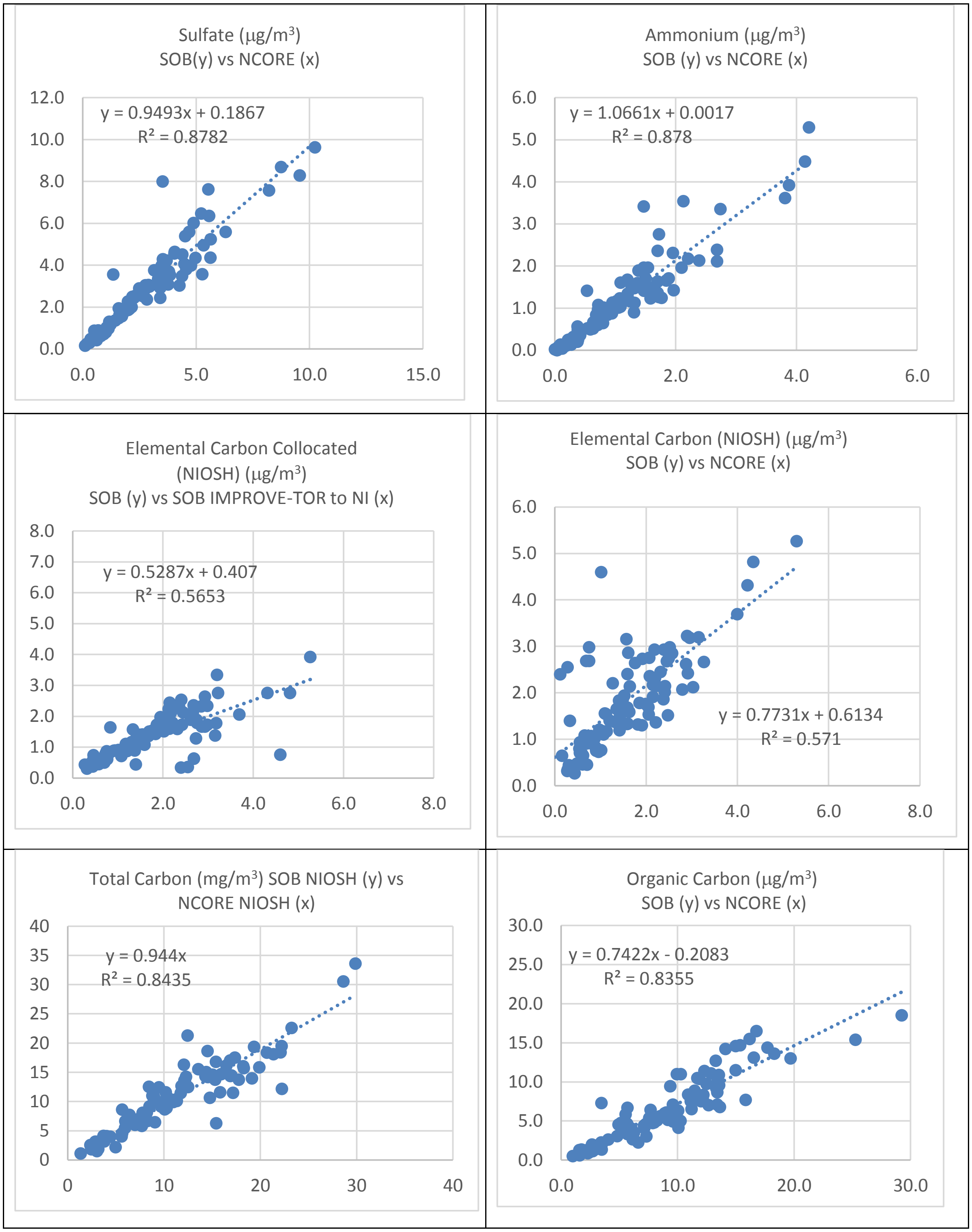


Figure 4-2. Correlation of NCore and SOB species from two winter seasons, 2011/12 and 2012/13

Since the above mentioned correlations of the two sites understate their similarities a relocation of the CSN site from SOB to the NCore site does not only make sense from a financial standpoint but will also combine the speciation dataset with the multi pollutant gaseous dataset collected at the NCore site. Future analysis of source mixes and the evaluation of control measures used to reduce $PM_{2.5}$ concentrations in Fairbanks will benefit from the data collection of a wide spectrum of compounds at one site.

4.1.2 Fairbanks $PM_{2.5}$ SLAMS Sites

DEC requests EPA to consider the suspension of the Fairbanks State Office Building (SOB) $PM_{2.5}$ SLAMS (FRM) monitors starting with the winter of 2015/16.

Below is a comparison of FRM data from both sites for the last four calendar years. The NCore site was established at its current location because an expansion of the SOB site was not possible and with the intent to absorb all the functions of the SOB site. DEC recognizes that the SOB $PM_{2.5}$ monitor is the violating monitor in the Fairbanks $PM_{2.5}$ non-attainment area, but believes that the NCore site can be used as a representative site for the Fairbanks downtown area for the long term.

Table 4-1 presents a comparison of summary statistics between the SOB and NCore sites for the calendar years 2010 through 2013.The data show that the concentrations at both sites are fairly consistent with minimal differences. The 2013 24-hour design values are only 1 µg/m^3 different, while the 2013 annual design values are identical.

Table 4-1 Summary Statistics for the Calendar Years 2010-2013 for $PM_{2.5}$ FRM data from the SOB and NCore sites

Summary statistics in µg/m^3								
	2010		2011		2012		2013	
	SOB	***NCore***	***SOB***	***NCore***	***SOB***	***NCore***	***SOB***	***NCore***
Mean	13.9	13.0	10.8	10.8	10.3	10.6	10.5	10.5
Standard Deviation	14.5	13.3	10.4	10.2	11.6	11.2	9.5	10.1
Minimum	0.6	1.1	1.0	0.0	0.0	0.5	1.2	0.2
Maximum	83.2	63.8	42.6	45.9	55.5	56.9	56	52.8
98th percentile	51.8	50.7	38.0	33.1	49.6	50.0	36.3	36.2
24 hour Design Value	50		47		46	45	41	40
Annual Design Value	11.7		11.5		11.2	11.4	10.7	10.7

The frequency distribution below (Figure 4-3) shows a pattern very similar to the summary statistics presented above. The frequency distribution is expressed in terms of the AQI index levels rather than concentration. There is no difference between the sites for AQI levels green (good air quality) and red (unhealthy air quality), and only a 0.9% difference in the number of days with yellow (moderate air quality) and orange (unhealthy air quality for sensitive groups) AQI levels. Both sites report that roughly 2/3 (67%) of the days in Fairbanks have air quality that is good, 26% moderate, and about 5% days unhealthy for sensitive groups or worse.

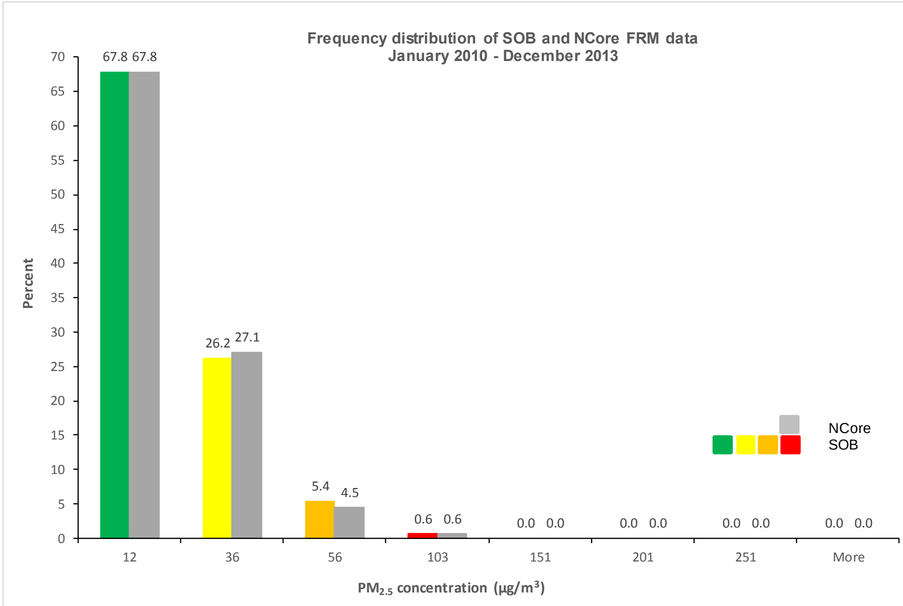


Figure 4-3. Frequency distribution of $PM_{2.5}$ concentrations for the Fairbanks SOB and NCore sites from January 2010 through December 2013

Both sites also correlate well on a daily basis, especially during the past two full calendar years (2012 and 2013) when $PM_{2.5}$ concentrations at both locations have shown strong agreement. The correlation coefficients for both years are above 0.97 (2012 r^2= 0.97 and 2013 r^2 = 0.98).Figures 4-4 shows linear correlations of the 24-hour $PM_{2.5}$ FRM measurements at both sites for 2012 and 2013, respectively.

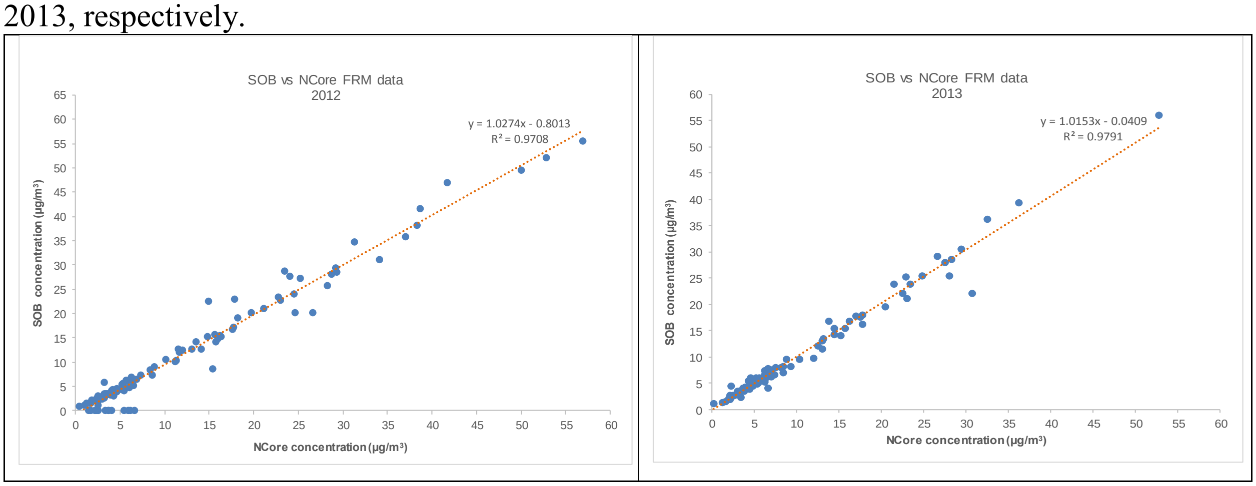


Figure 4-4. Correlation of the SOB $PM_{2.5}$ FRM and NCore FRM $PM_{2.5}$ data for 2012 on the left and 2013 on the right.

The overall linear correlation for 2012 shows a 3% difference in the slope, while the 2013 correlation shows a 1.5% difference. The daily differences between the sites are very small and below what would be considered acceptable for collocated samplers at a single site, so these sites should be considered identical, i.e. the measured differences are within the noise of the measurements.

According to 40 CFR 58.14 the State can request the discontinuation of a SLAMS monitoring site recording exceedances for logistical reasons only (c)(6). Section (c)(2) allows for removal of any of the other criteria pollutant monitoring sites if the site records lower concentrations than a similar site within the same distinct nonattainment area, but excludeds $PM_{2.5}$ from this rule. While DEC acknowledges that the FRM at the SOB is the violating monitor, the NCore site was established in close proximity to the SOB site for the purpose of absorbing the functions of that SOB SLAMS site. DEC believes that the intent of the rule is to ensure that no areas with air quality impacts are overlooked, not to create situations where two sites within the same neighborhood have to continue operations because both site record the same exceedance conditions. DEC believes the SOB site to be a redundant site. Therefore DEC requests EPA to consider suspending the SOB site after the 2014/15 winter until 40 CFR 58.14 can be reviewed and clarified.

4.1.3 Rural Alaska

DEC is committed to installing new $PM_{2.5}$ sites to assess fine particulate in rural Alaska. Working with the Alaska Native Tribal Health Consortium (ANTHC) and community leaders, DEC is planning to install a two-site network in Yakutat. The planned two-year study is to assess existing $PM_{2.5}$ concentrations and to evaluate impacts from the potential installation of new biomass boilers in the community. The Yakutat installation and startup is scheduled for the fall of 2014.

4.2 *Carbon Monoxide (CO) Network*

DEC proposes shutting down the Fairbanks Old Post Office CO site before the next CO sampling season begins on October 1, 2014. CO is currently also sampled at the Fairbanks NCORE site. A comparison of the data from both sites follows below.

CO sampling began at the NCore site in 2010 while the Old Post Office site has been in operation since 1972. No exceedances of the CO standard have been recorded in Fairbanks since 2000. During the past three sampling years, the hourly concentrations never rose above 7ppm for the 1-hour or 8-hour averages, respectively and the concentrations have decreased steadily over the past years. Table 4-2 summarizes the 1st and 2nd max concentrations for the 1-hour and 8 hour CO averages at the Old Post Office site and the NCORE site for 2011through 2013.

The maximum 1-hour CO concentration measured at the Old Post Office site in the past 3 years was 6.9 ppm (2012), compared to 4.7 ppm recorded at the NCore site that same year. These concentrations are less than 20% of the 1-hour National Ambient Air Quality Standard of 35 ppm.

The maximum 8-hour rolling average CO concentration measured during the past 3 years occurred in 2011 at the old Post Office site and was recorded as 6.9 ppm compared to 3.0 ppm measured at the NCore site during the same year or 3.5 ppm measured in 2013.

Both sites are located in downtown Fairbanks less than 0.25 miles apart. The Old Post Office site is situated in a busy street canyon on the south side of the Chena River and the NCore site is located in an open area on the north side of the river. The Old Post Office site was considered a maximum impact site that was chosen when vehicle emissions in Fairbanks caused winter-time CO exceedances.

Table 4-2 CO concentrations measured in Fairbanks

	Old Post Office		**NCORE**	
	1st max	2nd max	1st max	2nd max
1 hour average				
2011	6.9	5.4	3.0	2.6
2012	6.8	6.7	4.7	4.5
2013	5.9	4.9	3.8	2.8
8 hour moving average				
2011	6.9	5.4	3.0	2.6
2012	6.8	6.7	2.4	2.1
2013	3.6	3.5	3.5	2.7

The sample inlet passes through the eastern exterior wall of the building and extends out one meter at a height of two meters above the ground. The inlet is three meters from the nearest traffic lane on Cushman Street and ten meters (32 feet) from the intersection at 2nd Avenue. A traffic light backs up traffic past the inlet probe, effectively causing the sampler to measure idling vehicle emissions. Modern automotive technology has reduced vehicular CO emissions significantly, so that even under this siting scenario, the CO standards are met.

Currently elevated CO levels seem to be correlated with elevated $PM_{2.5}$ levels during inversions when overall pollution from all source categories are trapped close to the ground.

Access and budgetary issues make the Old Post Office site a non-desirable location for sampling. In recent years the building owners have had numerous tenants in the retail shop through which the FNSB staff gain access to the instrument room. These tenants have retail assets and administrative offices they want secured and so access and hours of operation vary from tenant to tenant. The limitations on access has presented challenges for the FNSB staff, causing technicians to make emergency access calls to address equipment issues. These emergency access requests are not always granted especially when they are not based on a fire or safety concern.

While the CO levels are consistently lower at the NCore site, DEC believes that the NCore site measurements are a conservative representation of CO concentrations found across Fairbanks. Because of the low CO concentrations recorded over many years and the siting issues discussed above, DEC recommends decommissioning the Old Post Office site and consolidating the CO monitoring network to one sampler at the NCore site.

APPENDIX A: NETWORK EVALUATION FORMS

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR CARBON MONOXIDE (CO)					
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST					
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
4.2.1(a)	One CO monitor is required to operate collocated with one required near-road NO_2 monitor in CBSAs having a population of 1,000,000 or more persons. If a CBSA has more than one required near-road NO_2 monitor, only one CO monitor is required to be collocated with a near-road NO_2 monitor within that CBSA.		√		
4.2.2(a)	Has the EPA Regional Administrator required additional CO monitoring stations above the minimum number of monitors required in 4.2.1? If so, note location in comment field.		√		
Comments: The State of Alaska has no CBSA with a population of 1,000,000: therefore, there are no near-road collocated sites for CO and NO_2. Two SLAMS sites for CO are currently operating in the Municipality of Anchorage for NAAQS compliance, the Garden Site (AQS ID 02-020-0018) and the Turnagain Site (AQS ID 02-020-0048). One CO SLAMS site is operating for NAAQS compliance in the Fairbanks North Star Borough, at the Old Post Office Building (AQS 02-090-0002). The Fairbanks North Star Borough also operates a CO monitor at the multi-pollutant Ncore site (AQS ID 02-090-0034).					

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR NITROGEN DIOXIDE (NO2)				
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST				
APPLICABLE SECTION	REQUIREMENT	CRITERIA MET?		
		YES	NO	N/A
4.3.2(a)	Near-road NO2 Monitors: One microscale near-road NO_2 monitoring station in each CBSA with a population of 500,000 or more persons.	√		
4.3.2(a)	Near-road NO2 Monitors: An additional near-road NO_2monitoring station is required for any CBSA with a population of 2,500,000 persons, or in any CBSA with a population of 500,000 or more persons that has one or more roadway segments with 250,000 or greater AADT count.	√		
4.3.2(b)	Near-road NO2 Monitors: Measurements at required near-road NO_2 monitor sites utilizing chemiluminescence FRMs must include at a minimum: NO, NO_2, and NO_X	√		
4.3.3(a)	Area-wide NO2 Monitoring: One monitoring station in each CBSA with a population of 1,000,000 or more persons to monitor a location of expected highest NO_2 concentrations representing the neighborhood or larger spatial scales.	√		

Comments: The State of Alaska has no CBSA with a population of 500,000 or more persons.

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR OZONE (O_3)				
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST				
APPLICABLE SECTION	REQUIREMENT	CRITERIA MET?		
		YES	NO	N/A
4.1(b)	At least one O_3 site for each MSA, or CSA if multiple MSAs are involved, must be designed to record the maximum concentration (note location in comment field).	√		
4.1(c)	The appropriate spatial scales for O_3 sites are neighborhood, urban, and regional (note deviations in comment field).	√		
4.1(f)	Confirm that the monitoring agency consulted with EPA R10 when siting the maximum O3 concentration site.	√		
4.1(i)	O3 is being monitored at SLAMS monitoring sites during the "ozone season" as specified in Table D-3 of Appendix D to Part 58.	√		

Comments: Ozone monitoring was established at the Municipality of Anchorage, Garden site (AQS ID 02-020-0018) as a SLAMS site in April 2010. This site was established to be representative of the combined MSAs for the Municipality of Anchorage and the Matanuska Valley Borough. Ozone monitoring was conducted at this site for three seasons 2010, 2011, and 2012. The ozone three-year design value was 0.045 ppm, which represents 60 percent of the NAAQS. Ozone monitoring was established at the Wasilla site (AQS ID 02- in the Matanuska-Susitna Valley Borough as a SPM site in 2011. Monitoring was conducted during the ozone seasons in 2011 and 2012. Equipment problems prevented the monitoring season in 2013 but monitoring was resumed beginning April 2014.

An ozone monitoring site was established in the Fairbanks North Star Borough at the multi-pollutant Ncore site (AQS 02-090-0034) in August 2011.

MSA Description[a]	MSA population[1, 2]	Minimum required number of SLAMS O3 sites (from Table D-2)	Present number of SLAMS O3 sites in CBSA	
Municipality of Anchorage	291,826 (2010)	0	0	
Matanuska-Susitna Valley Borough	88,995 (2010)	0	0	1 SPM site in Wasilla
Combined (MSAs)	380,821	1	0	3-years completed
Fairbanks North Star Borough	21,820	0	0	1 Ncore Site

[a]see http://www2.census.gov/econ/susb/data/msa_codes_2007_to_2011.txt

Table D-2 of Appendix D to Part 58 - SLAMS O3 Monitoring Minimum Requirements

MSA population[1, 2]	Most recent 3-year design value concentrations ≥85% of any O3 NAAQS[3]	Most recent 3-year design value concentrations <85% of any O3 NAAQS[3, 4]
>10 million	4	2
4-10 million	3	1
350,000-<4 million	2	1
50,000-<350,000[5]	1	0

[1]Minimum monitoring requirements apply to the Metropolitan statistical area (MSA). CBSA includes both MSAs and micropolitan statistical areas.
[2]Population based on latest available census figures.
[3]The ozone (O3) National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.
[4]These minimum monitoring requirements apply in the absence of a design value.
[5]Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population

Table D-3 of Appendix D to Part 58 – Ozone Monitoring Season for Alaska begins April through October

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR PM10				
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST				
APPLICABLE SECTION	REQUIREMENT	CRITERIA MET?		
		YES	NO	N/A
4.6(a)	Table D-4 indicates the approximate number of permanent stations required in MSAs to characterize national and regional PM10 air quality trends and geographical patterns. Use the form below and Table D-4 to verify if your PM10 network has to appropriate number of samplers.	√		
Comments: All of the site locations are based on historical agreements among the EPA, ADEC and (where applicable) local agencies.				

MSA Description[1]	MSA population[2, 3]	Minimum required number of PM10 stations (from Table D-4)	Present number of PM10 stations in MSA
Municipality of Anchorage	291,826	3	3 (2 SLAMS, 1 SPM)
Matanuska-Susitna Valley Borough	88,995	1	3 (1 SLAMS, 2 SPM)
Fairbanks North Star Borough	97,581	1	1 (1 Ncore)
City and Borough of Juneau	31,275	1	2 (collocated)
Kenai Peninsula Borough (Soldotna)	55,400	0	1 (SPM)

[1]see http://www2.census.gov/econ/susb/data/msa_codes_2007_to_2011.txt
[2]Minimum monitoring requirements apply to the **Metropolitan statistical area (MSA). CBSA includes both MSAs and** micropolitan statistical areas.
[3]Population based on latest available census figures.

Table D-4 of Appendix D to Part 58 – PM10 Minimum Monitoring Requirements			
MSA population[1, 2]	High concentration2	Medium concentration3	Low concentration4 5
>1 million	6-10	4-8	2-4
500K to 1 million	4-8	2-4	1-2
250K to 500K	3-4	1-2	0-1
100K to 250K	1-2	0-1	0

[1]Selection of urban areas and actual numbers of stations per area will be jointly determined by EPA and the State agency.
[2]High concentration areas are those for which ambient PM10 data show ambient concentrations exceeding the PM10 NAAQS by 20 percent or more.
[3]Medium concentration areas are those for which ambient PM10 data show ambient concentrations exceeding 80 percent of the PM10 NAAQS.
[4]Low concentration areas are those for which ambient PM10 data show ambient concentrations less than 80 percent of the PM10 NAAQS.
[5]These minimum monitoring requirements apply in the absence of a design value.

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR PM2.5 Page 1 of 2				
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST				
APPLICABLE SECTION	REQUIREMENT	CRITERIA MET?		
		YES	NO	N/A
4.7.1(a)	States, and where applicable local agencies must operate the minimum number of required $PM_{2.5}$ SLAMS sites listed in Table D-5 of this appendix. Use the form below and Table D-5 to verify if each of your MSAs have the appropriate number of SLAMS FRM/FEM/ARM samplers.	X		
4.7.1(b)	Each required SLAMS FRM/FEM/ARM monitoring stations or sites must be sited to represent area-wide air quality in the given MSA (typically neighborhood or urban spatial scale, though micro-or middle-scale okay if it represent many such locations throughout the MSA).	X		
4.7.1(b)(1)	At least one SLAMS FRM/FEM/ARM monitoring station is to be sited at neighborhood or larger scale in an area of expected maximum concentration for each MSA where monitoring is required by 4.7.1(a).	X		
4.7.1(b)(2)	For CBSAs with a population of 1,000,000 or more persons, at least one FRM/FEM/ARM $PM_{2.5}$ monitor is to be collocated at a near-road NO_2 station.			X
4.7.1(b)(3)	For MSAs with additional required SLAMS sites, a FRM/FEM/ARM monitoring station is to be sited in an area of poor air quality.	X		
4.7.2	Each State must operate continuous $PM_{2.5}$ analyzers equal to at least one-half (round up) the minimum required sites listed in Table D-5 of this appendix. At least one required continuous analyzer in each MSA must be collocated with one of the required FRM/FEM/ARM monitors, unless at least one of the required FRM/FEM/ARM monitors is itself a continuous FEM or ARM monitor, in which case no collocation requirement applies.	X		
4.7.3	Each State shall install and operate at least one $PM_{2.5}$ site to monitor for regional background and at least one $PM_{2.5}$ site to monitor regional transport (note locations in comment field). Non-reference PM2.5 monitors such as IMPROVE can be used to meet this requirement.	X		
4.7.4	Each State shall continue to conduct chemical speciation monitoring and analyses at sites designated to be part of the $PM_{2.5}$ Speciation Trends Network (STN).	X		
Comments: In regards to requirement 40 CFR 58, Appendix D 4.7.3, ADEC will use the Trapper Creek IMPROVE site as the $PM_{2.5}$ background site. A monitoring location is yet to be designated as the PM2.5 transport site.				

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR PM2.5 Page 2 of 2						
MSA Description[1]	MSA population[2,3]	Design Value for years 2011-2013 24-hr/Annual Avg. µg/m³	Minimum required number of PM2.5 SLAMS FRM/FEM/ARM sites (from Table D-5)	Present number of PM2.5 SLAMS FRM/FEM/ARM sites in MSA	Present number of continuous PM2.5 FEM/ARM analyzers in MSA	Present number of continuous PM2.5 STN analyzers in MSA
Municipality of Anchorage	291,826		0	2	2	0
Garden Site		20/5.6	SLAMS/FEM	1	1	
Parkgate		16/5.0	SLAMS/FEM	1	1	
Matanuska-Susitna Valley Borough	88,995		1	1	3	0
Butte Site		31/6.3	SLAMS/RFM & FEM	1	1	
Palmer Site		11/3.8	SPM/RFM & FEM	1	1	
Wasilla Site		18/5.3	SPM/FEM	1	1	
Fairbanks North Star Borough	97,581		1	4		3 speciation
State Office Building		42/11.2	SLAMS/RFM	1		2 speciation
Ncore Site		45/11.1	NCore/2 FRM	2 (collocated)		
North Pole		140/23.0*	SPM/RFM	1		1 speciation
City and Borough of Juneau	27,940		0	1	1	0
Floyd Dryden Site		24/6.5	SLAMS/FEM	1	1	
Kenai Peninsula Borough	55,400		0			0
Soldotna Site		8/1.7*	SPM/FEM	1	1	

[1]see http://www2.census.gov/econ/susb/data/msa_codes_2007_to_2011.txt)

[2]Minimum monitoring requirements apply to the metropolitan statistical area (MSA). CBSA includes both MSAs and micropolitan statistical areas.

[3]Population based on latest available census figures.

* Design calculations are not valid based on data completeness.

Table D-5 of Appendix D to Part 58 – PM2.5 Minimum Monitoring Requirements		
MSA population[1, 2]	Most recent 3-year design value ≥85% of any PM2.5 NAAQS[3]	Most recent 3-year design value <85% of any PM2.5 NAAQS[3, 4]
>1 million	3	2
500K to 1 million	2	1
50K to <500K[5]	1	0

[1]Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).
[2]Population based on latest available census figures. https://www.census.gov/
[3]The $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.
[4]These minimum monitoring requirements apply in the absence of a design value.
[5]Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

PART 58 APPENDIX D NETWORK EVALUATION FORM FOR SULFUR DIOXIDE (SO_2)				
STATE: ALASKA **AGENCY:** DEPARTMENT OF ENVIRONMENTAL CONSERVATION **AQS AGENCY CODE:** 02 **EVALUATION DATE**: April 14, 2014 **EVALUATOR:** ROBERT MORGAN, ENV. PROGRAM SPECIALIST				
APPLICABLE SECTION	REQUIREMENT	CRITERIA MET?		
		YES	NO	N/A
4.4.1	State and, where appropriate, local agencies must operate a minimum number of required SO_2 monitoring sites (based on PWEI calculation specified in 4.4.2 – use Table 1 and 2 below to determine minimum requirement for each CBSA)	√		
4.4.2(a)(1)	Is the monitor sited within the boundaries of the parent CBSA and is it one of the following site types: population exposure, highest concentration, source impacts, general background, or regional transport?			√
4.4.3(a)	Has the EPA Regional Administrator required additional SO_2 monitoring stations above the minimum number of monitors required in 4.4.2? If so, note location in comment field.		√	
4.4.5(a)	Is your agency counting an existing SO2 monitor at an NCore site in a CBSA with a minimum monitoring requirement?			√
Comments: As evident from the calculations shown below, the State of Alaska has no CBSAs which require SO_2 monitoring. The operating SO_2 monitor is located at the multi-pollutant Ncore site in the Fairbanks North Star Borough.				

Table 1.

CBSA Description[1]	CBSA population[1, 2]	total amount of SO2 in tons per year emitted within the CBSA (use 2008 NEI[4])	PWEI (population x total emissions ÷ 1,000,000)	Minimum required number of SO2 monitors in CBSA (see Table 2 below)	Present number of SO2 monitors in CBSA
Municipality of Anchorage	291,826	746.8	217.9	0	0
Fairbanks North Star Borough	97,581	2,614.3	255.1	0	1
Matanuska-Susitna Valley Borough	88,995	226.9	20.2	0	0
Juneau	31.275	1,198.8	37.5	0	0
North Slope Borough	9,430	1,722.1	16.2	0	0

[1]see http://www.census.gov/population/metro/data/def.html
[2]Minimum monitoring requirements apply to the Core Based statistical area (CBSA). CBSA includes both metropolitan and micropolitan statistical areas.
[3]Population based on latest available census figures.
[4]see http://www.epa.gov/ttn/chief/eiinformation.html

Table 2. Minimum SO2 Monitoring Requirements (Section 4.4.2 of App D to Part 58)

PWEI (Population weighted Emission Index) Value	Require number of SO2 monitors
>= 1,000,000	3
>= 100,000 but < 1,000,000	2
>= 5,000 but < 100,000	1

APPENDIX B: MONITORING PATH & SITING CRITERIA EVALUATION FORMS

Anchorage Municipality Monitoring Sites

PART 58 APPENDIX E SITE EVALUATION FORM FOR CO					
SITE NAME: Garden AQS ID: 02-020-0018	SITE ADDRESS: 3000 E 16th Ave, Anchorage EVALUATION DATE: 4/10/2014	EVALUATOR: C. Salerno			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	For neighborhood or larger spatial scale sites the probe must be located 2-15 meters above ground level and must be at least 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Probe height 3 meters	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet (exception is street canyon or source-oriented sites where buildings and other structures are unavoidable).		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.	1*		X	
	(c) No trees should be between source and probe inlet for microscale sites.	2*		X	
6. SPACING FROM ROADWAYS	2. (b) Microscale CO monitor probes in downtown areas or urban street canyon locations shall be located a minimum distance of 2 meters and a maximum distance of 10 meters from the edge of the nearest traffic lane.				X
	2. (c) Microscale CO monitor inlet probes in downtown areas or urban street canyon locations shall be located at least 10 meters from an intersection and preferably at a midblock location.				X
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex) for reactive gases.		X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.			X	
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.					X
Other Comments: Trees have grown slightly					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)
≤10,000	10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
≥60,000	150

[1] Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

1* Tree dripline is approximately 5 meters from probe inlet
2* One white spruce between probe and 16th street

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Garden SITE ADDRESS: 3000 E 16th Ave, Anchorage AQS ID: 02-020-0018 EVALUATION DATE: 4/10/2014 EVALUATOR: C. Salerno					
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Roof height 6 meters. All PM inlets 8 meters	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.		X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments: ADT ≤ 10,000 traffic lane 14 meters north of probe					

PART 58 APPENDIX E SITE EVALUATION FORM FOR CO					
SITE NAME: Turnagain	SITE ADDRESS: 3201 Turnagain St, Anchorage				
AQS ID: 02-020-0048	EVALUATION DATE: 4/10/2014	EVALUATOR: C. Salerno			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	For neighborhood or larger spatial scale sites the probe must be located 2-15 meters above ground level and must be at least 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Probe height 3 meters	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet (exception is street canyon or source-oriented sites where buildings and other structures are unavoidable).		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.	1*		X	
	(c) No trees should be between source and probe inlet for microscale sites.	2*		X	
6. SPACING FROM ROADWAYS	2. (b) Microscale CO monitor probes in downtown areas or urban street canyon locations shall be located a minimum distance of 2 meters and a maximum distance of 10 meters from the edge of the nearest traffic lane.				X
	2. (c) Microscale CO monitor inlet probes in downtown areas or urban street canyon locations shall be located at least 10 meters from an intersection and preferably at a midblock location.				X
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex) for reactive gases.		X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.				X
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments: Trees have grown slightly					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)
≤10,000	10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
≥60,000	150

[1] Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

1* Tree drip line approximately 6 meters from probe inlet
2* Three white spruce between probe and turnagain

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Tudor AQS ID: 02-020-0044	SITE ADDRESS: 3335 E Tudor Rd, Anchorage EVALUATION DATE: 4/10/2014	EVALUATOR: C. Salerno			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Roof height 3.3 meters Probe inlet 5.3 meters	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.	1*	X		
	(c) No trees should be between source and probe inlet for microscale sites.	2*	X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.	3*	X		
Are there any changes that might compromise original siting criteria? Trees have grown slightly				X	
Other Comments: 1* 5 meter distance between drip line of trees and sampler 2* 6 meter tall trees source/roadway and sampler do not significantly exceed height of sampler 3* ADT is approximately 35,000 (2012) Tudor traffic lane 7 meters south					

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Parkgate AQS ID: 02-020-1004	EVALUATION DATE: 4/10/2014	SITE ADDRESS: 11723 Old Glenn Hwy, Eagle River EVALUATOR: C. Salerno			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Roof height 5 meters Probe inlet 7 meters	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.		X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments: ADT~17,600 (2012) on Old Glenn Hwy, Traffic lane 44 meters east Easystreet, traffic lane 23 meters south					

Fairbanks North Star Borough Monitoring Sites

PART 58 APPENDIX E SITE EVALUATION FORM FOR CO					
SITE NAME: FNSB-Ncore AQS ID: 02-090-0034 EVALUATION DATE: 4/10/14	SITE ADDRESS: 905 Pioneer Rd, Fairbanks EVALUATOR: Ron Lovell				
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	For neighborhood or larger spatial scale sites the probe must be located 2-15 meters above ground level and must be at least 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet (exception is street canyon or source-oriented sites where buildings and other structures are unavoidable).		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	2. (b) Microscale CO monitor probes in downtown areas or urban street canyon locations shall be located a minimum distance of 2 meters and a maximum distance of 10 meters from the edge of the nearest traffic lane.		X		
	2. (c) Microscale CO monitor inlet probes in downtown areas or urban street canyon locations shall be located at least 10 meters from an intersection and preferably at a midblock location.		X		
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex) for reactive gases.		X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.		X		
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments:					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)
≤10,000	10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
≥60,000	150

[1] Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

PART 58 APPENDIX E SITE EVALUATION FORM FOR O3					
SITE NAME: FNSB-Ncore AQS ID: 02-090-0034	EVALUATION DATE: 4/10/14	SITE ADDRESS: 905 Pioneer Rd, Fairbanks EVALUATOR: Ron Lovell			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
	(b) To minimize scavenging effects, the probe inlet must be away from furnace or incineration flues or other minor sources of SO_2 or NO.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	See spacing requirements table below		X		
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex).		X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.		X		
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments:					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)	Minimum distance[1, 2] (meters)
≤1,000	10	10
10,000	10	20
15,000	20	30
20,000	30	40
40,000	50	60
70,000	100	100
≥110,000	250	250

[1]Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

[2]Applicable for ozone monitors whose placement has not already been approved as of December 18, 2006.

PART 58 APPENDIX E SITE EVALUATION FORM FOR SO2					
SITE NAME: FNSB-Ncore AQS ID: 02-090-0034 EVALUATION DATE: 4/10/14		SITE ADDRESS: 905 Pioneer Rd, Fairbanks EVALUATOR: Ron Lovell			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	There are no roadway spacing requirements for SO2.				X
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex).		X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.		X		
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments:					

PART 58 APPENDIX E SITE EVALUATION FORM FOR NO, NOx, NO2, and NOy					
SITE NAME: FNSB-Ncore AQS ID: 02-090-0034	EVALUATION DATE: 4/10/14	SITE ADDRESS: 905 Pioneer Rd, Fairbanks EVALUATOR: Ron Lovell			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	For neighborhood or larger spatial scale sites the probe must be located 2-15 meters above ground level and must be at least 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. Microscale near-road NO_2 monitoring sites are required to have sampler inlets between 2 and 7 meters above ground level. If located near the side of a building or wall, then locate the sampler probe on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale and larger avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.		X		
	(d) For near-road NO_2 monitoring stations, the monitor probe shall have an unobstructed air flow, where no obstacles exist at or above the height of the monitor probe, between the monitor probe and the outside nearest edge of the traffic lanes of the target road segment.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	See spacing requirements table below		X		
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex).		X		
	(c) Sampling probes for reactive gas monitors at NCore and at NO_2 sites must have a sample residence time less than 20 seconds.		X		
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments:					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)	Minimum distance[1, 2] (meters)
≤1,000	10	10
10,000	10	20
15,000	20	30
20,000	30	40
40,000	50	60
70,000	100	100
≥110,000	250	250

[1]Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

[2]Applicable for ozone monitors whose placement has not already been approved as of December 18, 2006.

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: FNSB-Ncore AQS ID: 02-090-0034	EVALUATION DATE: 4/10/14		SITE ADDRESS: 905 Pioneer Rd, Fairbanks EVALUATOR: Ron Lovell		
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.		X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

<table>
<tr><td colspan="6">PART 58 APPENDIX E SITE EVALUATION FORM FOR CO</td></tr>
<tr><td colspan="6">SITE NAME: Old Post Office SITE ADDRESS: 250 Cushmen St, Fairbanks
AQS ID: 02-090-0002 EVALUATION DATE: 4/28/14 EVALUATOR: McCormick</td></tr>
<tr><td>APPLICABLE SECTION</td><td>REQUIREMENT</td><td>OBSERVED</td><td colspan="3">CRITERIA MET?</td></tr>
<tr><td></td><td></td><td></td><td>YES</td><td>NO</td><td>N/A</td></tr>
<tr><td>2. HORIZONTAL AND VERTICLE PLACEMENT</td><td>For neighborhood or larger spatial scale sites the probe must be located 2-15 meters above ground level and must be at least 1 meter vertically or horizontally away from any supporting structure, walls, etc., and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.</td><td>1m-building
3.3m-good</td><td>X</td><td></td><td></td></tr>
<tr><td>3. SPACING FROM MINOR SOURCES</td><td>(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td rowspan="2">4. SPACING FROM OBSTRUCTIONS</td><td>(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet (exception is street canyon or source-oriented sites where buildings and other structures are unavoidable).</td><td>Street canyon</td><td>X</td><td></td><td></td></tr>
<tr><td>(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td rowspan="2">5. SPACING FROM TREES</td><td>(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>(c) No trees should be between source and probe inlet for microscale sites.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td rowspan="2">6. SPACING FROM ROADWAYS</td><td>2. (b) Microscale CO monitor probes in downtown areas or urban street canyon locations shall be located a minimum distance of 2 meters and a maximum distance of 10 meters from the edge of the nearest traffic lane.</td><td>4m</td><td>X</td><td></td><td></td></tr>
<tr><td>2. (c) Microscale CO monitor inlet probes in downtown areas or urban street canyon locations shall be located at least 10 meters from an intersection and preferably at a midblock location.</td><td>12m</td><td>X</td><td></td><td></td></tr>
<tr><td rowspan="2">9. PROBE MATERIAL & RESIDENCE TIME</td><td>(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex) for reactive gases.</td><td>Teflon</td><td>X</td><td></td><td></td></tr>
<tr><td>(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.</td><td>Non-reactive</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="3">Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Other Comments:</td></tr>
</table>

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)
≤10,000	10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
≥60,000	150

[1] Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: FSOB AQS ID: 02-090-0010	EVALUATION DATE: 4/11/14	SITE ADDRESS___________________ EVALUATOR: Paul Wright			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.		X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: NPF3 SITE ADDRESS: 3288 Hurst Rd, North Pole AQS ID: 02-090-0035 EVALUATION DATE: 4/11/2014 EVALUATOR: Paul Wright					
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.		X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.		X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments: There is a group of three trees to the north of the inlet. The distance from the probe inlet to the drip line of the tree is just within acceptance criteria. Future growth may require the tree to be trimmed to meet acceptance criteria.					

Matanuska-Susitna Valley Monitoring Sites

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Butte AQS ID: 02-170-0008	SITE ADDRESS: Harrison Ct, Butte EVALUATION DATE: 04/16/14	EVALUATOR: Daniella Fawcett, Ryan Dukowitz			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Trees>10m	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.	Paved road, gravel cul de sac	X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	No obstacles	X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.	No obstacles	X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.	Trees>10m	X		
	(c) No trees should be between source and probe inlet for microscale sites.				X
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.	Road>100m away	X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Palmer SITE ADDRESS: S Gulkana St, Palmer AQS ID: 02-170-0012 EVALUATION DATE: 04/16/14 EVALUATOR: Daniella Fawcett, Ryan Dukowitz					
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10\text{-}2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Sampling inlet>3m above ground No walls >600m	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.	Raved roads only No sources nearby	X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	No obstacles Nearest tree>100m	X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.	No obstacles	X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.	Nearest tree>100m	X		
	(c) No trees should be between source and probe inlet for microscale sites.				X
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.	Road>20m away	X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb

SITE NAME: Wasilla SITE ADDRESS: 100 block of W Swanson Ave, Wasilla

AQS ID: 02-170-0013 EVALUATION DATE: 4/16/14 EVALUATOR: Daniella Fawcett, Ryan Dukowitz

APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10\text{-}2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	Inlet >3m above ground	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.	Only paved roads nearby	X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	No obstacles	X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.	No obstacles	X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.	Nearest tree >10m away from sampling site	X		
	(c) No trees should be between source and probe inlet for microscale sites.				X
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.	Road >20m away from sampling site	X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

PART 58 APPENDIX E SITE EVALUATION FORM FOR O3					
SITE NAME: Wasilla SITE ADDRESS: 100 block of W Swanson Ave, Wasilla AQS ID: 02-170-0013 EVALUATION DATE: 04/16/14 EVALUATOR: Daniella Fawcett, Ryan Dukowitz					
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	The sampling inlet is about 4m above the ground	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood scale avoid placing the monitor probe inlet near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site.	No sources	X		
	(b) To minimize scavenging effects, the probe inlet must be away from furnace or incineration flues or other minor sources of SO_2 or NO.	No sources	X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the probe inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	No obstacles	X		
	(b) The probe inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential.	No obstacles	X		
5. SPACING FROM TREES	(a) To reduce possible interference the probe inlet must be at least 10 meters or further from the drip line of trees.	Closest trees >10m away from sampling site	X		
	(c) No trees should be between source and probe inlet for microscale sites.				X
6. SPACING FROM ROADWAYS	See spacing requirements table below	Road >20m away from sampling site	X		
9. PROBE MATERIAL & RESIDENCE TIME	(a) Sampling train material must be FEP Teflon or borosilicate glass (e.g., Pyrex).	FEP Teflon	X		
	(c) Sampling probes for reactive gas monitors at NCore must have a sample residence time less than 20 seconds.				X
Are there any changes that might compromise original siting criteria? If so, provide detail in comment section.				X	
Other Comments:					

Roadway average daily traffic, vehicles per day	Minimum distance[1] (meters)	Minimum distance[1, 2] (meters)
≤1,000	10	10
10,000	10	20
15,000	20	30
20,000	30	40
40,000	50	60
70,000	100	100
≥110,000	250	250

[1]Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

[2]Applicable for ozone monitors whose placement has not already been approved as of December 18, 2006.

City and Borough of Juneau Monitoring Site

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Floyd Dryden AQS ID 02-110-0004	SITE ADDRESS: Mendenhall Valley, Juneau EVALUATION DATE: 4/28/14	EVALUATOR: Gus van Vliet			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.	8m	X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	Inlet height 8 m, Tree height 40 m, Acceptable distance 64 m, Actual distance of separation 29 m		X	
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.				X
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.				X
Are there any changes that might compromise original siting criteria?				X	
Other Comments: The distance of separation between the probe inlet and the tree line is 29 meters as compared to the calculated acceptance criteria for Item 4(a) of 64 meters. These are old growth Spruce trees and these measurements have remained approximately the same since monitoring began at this long-term site. Although the separation distances do not meet the criteria, the spacing and coverage of surrounding tall trees is representative for the Mendenhal Valley neighborhood.					

Kenai Peninsula Borough Monitoring Site

PART 58 APPENDIX E SITE EVALUATION FORM FOR PM2.5, PM10, PM10-2.5,and Pb					
SITE NAME: Soldotna AQS ID 02-122-0008	SITE ADDRESS: 144 N Binkley Street and corner of Shady Lane, Soldotna, AK EVALUATION DATE: 3/14/14, 4/16/14	EVALUATOR: Ryan Dukowitz, Mary Pfauth			
APPLICABLE SECTION	REQUIREMENT	OBSERVED	CRITERIA MET?		
			YES	NO	N/A
2. HORIZONTAL AND VERTICLE PLACEMENT	2-15 meters above ground level for neighborhood or larger spatial scale, 2-7 meters for microscale spatial scale sites and middle spatial scale $PM_{10-2.5}$ sties. 1 meter vertically or horizontally away from any supporting structure, walls, *etc.,* and away from dusty or dirty areas. If located near the side of a building or wall, then locate on the windward side relative to the prevailing wind direction during the season of highest concentration potential.		X		
3. SPACING FROM MINOR SOURCES	(a) For neighborhood or larger spatial scales avoid placing the monitor near local, minor sources. The source plume should not be allowed to inappropriately impact the air quality data collected at a site. Particulate matter sites should not be located in an unpaved area unless there is vegetative ground cover year round.		X		
4. SPACING FROM OBSTRUCTIONS	(a) To avoid scavenging, the inlet must have unrestricted airflow and be located away from obstacles. The separation distance must be at least twice the height that the obstacle protrudes above the probe inlet.	No obstacles	X		
	(b) The inlet must have unrestricted airflow in an arc of at least 180 degrees. This arc must include the predominant wind direction for the season of greatest pollutant concentration potential. For particle sampling, a minimum of 2 meters of separation from walls, parapets, and structures is required for rooftop site placement.		X		
5. SPACING FROM TREES	(a) To reduce possible interference the inlet must be at least 10 meters or further from the drip line of trees.		X		
	(c) No trees should be between source and probe inlet for microscale sites.		X		
6. SPACING FROM ROADWAYS	Spacing from roadways is dependent on the spatial scale and ADT count. See section 6.3(b) and figure E-1 for specific requirements.	40 ft	X		
Are there any changes that might compromise original siting criteria?				X	
Other Comments:					

APPENDIX C: ADDITIONAL MONITORING PROJECTS

Smoke Monitoring for Air Quality Advisories

Smoke from wildland fires can affect large areas and impacts air quality in regions both close to and far away from the burning fire. Almost every summer, large areas of the State are impacted by smoke from wild fires, with air quality degrading into the very unhealthy to hazardous range. DEC assists the Alaska Fire Service in assessing air quality impacts in areas affected by fires and provides information needed to protect public health. The DEC Air Quality Division uses two separate methods to assess air quality impacts and issue air quality advisories statewide: monitoring data and visibility information. Often a combination of both data sets is used to issue air quality advisories. The DEC meteorologist or AQ staff with assistance from the NWS use meteorological and air monitoring data to forecast smoke movement and predict where air quality impacts might be experienced.

DEC, with the help of local site operators, currently operates two continuous analyzers in rural Alaska during the wild fire season: Galena and Ft Yukon. DEC also has two portable, battery-operated, continuous particulate matter monitors (E-BAM) equipped with satellite communication devices, which can transmit the data to a website. The E-BAM instrument requires little maintenance and staff is typically only needed at set-up and to ensure proper operation for the first day. Remote data access allows staff in the DEC office or in the field to use the data for advisories and briefings. Currently no additional samplers are requested, as staff time and travel funds are the limiting factor in expanding the smoke monitoring network.

Mercury Monitoring

DEC received funding through the Alaska Coastal Impact Assessment program to expand the current network of two Mercury Deposition Network (MDN) sites (measuring wet deposition mercury) as part of the National Atmospheric Deposition Program (NADP) in Kodiak and in Unalaska (Dutch Harbor). This funding supports the laboratory analysis of the Kodiak and Unalaska samples to include the following trace metals: lead, cadmium, copper, nickel, zinc, chromium, beryllium, arsenic, and selenium. These compounds are typically found in the exhaust of major stationary sources and have been used to identify source emission signatures. In addition, one new wet deposition monitoring site in Nome will be established to measure mercury deposition along with the above mentioned trace metal contaminants in rain or snowfall. This Alaska Coastal Deposition Network, consisting of the new site and the existing sites in Kodiak and Unalaska will be operated using the techniques and quality assurance protocols of the MDN, managed by the NADP.

The data gathered by the Alaska Coastal Deposition Network will be used to determine if deposition is localized or if Alaska’s coastal ecosystem is uniformly impacted. As airborne transport is the major contamination pathway, the data collected should be considered essential for use in preventative ecosystem management. Increases in airborne pollutants will slowly make their way into the ecosystem, thus deposition data can be used to predict future ecosystem impacts, plan mitigation strategies, and assist ecosystem management. In addition, deposition data can be used to develop and corroborate models for mitigation strategies and opportunities.

Working with DEC and National Weather Service meteorologists and atmospheric scientists schooled in the analysis of back trajectories, the trace metal and mercury data will be combined with local and global meteorological data to assess long range and short range transport patterns to identify potential local, regional and international source regions. The mercury data will be available on the MDN web page. The trace metal data will be stored in a database at the DEC AQ office and will be linked with the mercury and meteorological data. The reports will be shared with the fish tissue monitoring program and any interested parties. A final report will be posted on the DEC web page.

Radiation Monitoring

The State has three radiation monitoring network sites (RadNet) located in Anchorage, Fairbanks and Juneau. Various agencies and groups operate the equipment. The site in Anchorage is operated by the Alaska Department of Health and Social Services. The University of Alaska Fairbanks operates the Fairbanks site. The DEC Air Quality Division operates the site in Juneau. A decision needs to be made if these sites are intended as early warning stations or to document radiation levels experienced throughout the state. If early warning is the goal, the sites in Anchorage and Fairbanks are not the best locations to meet this objective. The sites should either be moved to the coast to allow for early detection and actions before the radiation reaches the population centers inland or additional coastal monitors should be installed to meet this need.

APPENDIX D: IMPROVE NETWORK

In 1977, Congress amended the Clean Air Act to include provisions to protect the scenic vistas of the nation's national parks and wilderness areas. In these amendments, Congress declared as a national visibility goal:

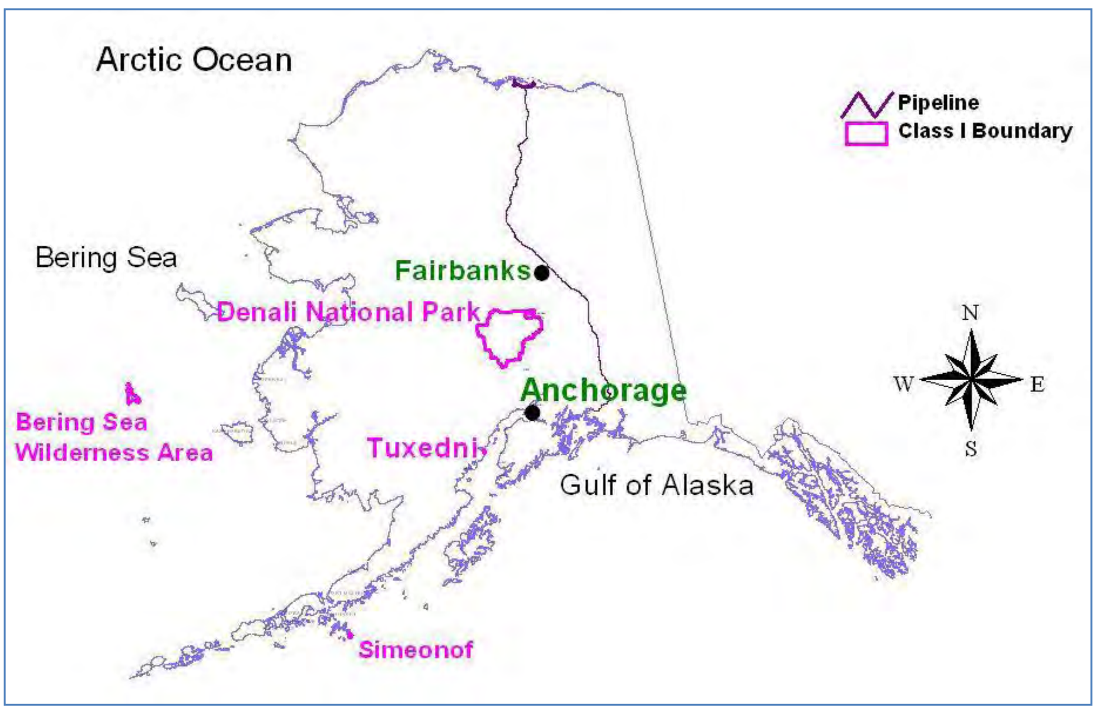
> *The prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution. (Section 169A)*

At that time, Congress designated all wilderness areas over 5,000 acres and all national parks over 6,000 acres as mandatory federal Class I areas. These Class I areas receive special visibility protection under the Clean Air Act.

The 1990 amendments to the Clean Air Act established a new Section 169(B) to address regional haze. To address the 1990 Clean Air Act amendments, the problem of long-range transport of pollutants causing regional haze, and to meet the national goal of reducing man-made visibility impairment in Class I areas, EPA adopted the Regional Haze Rule in 1999.

Alaska has four Class I areas subject to the Regional Haze Rule: Denali National Park, Tuxedni National Wildlife Refuge, Simeonof Wilderness Area, and Bering Sea Wilderness Area. They were designated Class I areas in August 1977. Figure 1 shows their locations, with Denali National Park in the Interior, Tuxedni and Simeonof Wilderness Areas as coastal, and the Bering Sea Wilderness Area.

Figure 1-Alaskan Class I Areas



In Alaska, Class I Areas are managed by the National Park Service (NPS) and the U.S. Fish and Wildlife Service (USFWS.)

The Alaska Regional Haze SIP includes a monitoring plan for measuring, estimating and characterizing air quality and visibility impairment at Alaska's four Class I areas. The haze species concentrations are measured as part of the IMPROVE monitoring network deployed throughout the United States. Alaska uses four IMPROVE monitoring stations representing three of the four Class I Areas. Three of these stations (Denali National Park and Preserve, Simeonof, and Tuxedni) were deployed specifically in response to Regional Haze rule requirements. There is no air monitoring being conducted at the Bering Sea Wilderness Area due to its remote location.

Denali National Park and Preserve

Denali National Park and Preserve (DNPP) is a large park in the interior of Alaska. It has kept its integrity as an ecosystem because it was set aside for protection fairly early in Alaska's history. Denali National Park headquarters lies 240 miles north of Anchorage and 125 miles southwest of Fairbanks, in the center of the Alaska Range. The park area totals more than 6 million acres. Denali is the only Class I site in Alaska that is easily accessible and connected to the road system. Denali has the most extensive air monitoring of Alaska's Class I areas, so more detailed examinations of long-term and seasonal air quality trends are possible for this site.

IMPROVE monitoring sites were established at two locations within or near the boundaries of the National Park and Preserve. The first air monitoring site is located near the eastern end of the park road at the Park Headquarters. A second, newer site, known as Trapper Creek, is located to the south of the Park at another site with reliable year-round access and electrical power.

The Denali Headquarters monitoring site (DENA1) is across the Park Road from park headquarters, approximately 250 yards from headquarters area buildings. The site (elevation of 2,125 feet) sits above the main road (elevation 2,088 feet). The side road to the monitoring site winds uphill for 130 yards, providing access to the monitoring site and a single-family residential staff cabin. The hill is moderately wooded, but the monitoring site sits in a half an acre clearing. During the park season, mid-May to mid-September, 70 buses and approximately 560 private vehicles per day loaded with park visitors traverse the road. During the off season, approximately100 passenger and maintenance vehicles pass within 0.3 miles of the monitoring site. Private vehicles are only allowed on the first 14.8 miles of the Park Road.

The Trapper Creek IMPROVE monitoring site (TRCR1) is located 100 yards east of the Trapper Creek Elementary School. The site is located west of Trapper Creek, Alaska and a quarter mile south of Petersville Road. The site is the official IMPROVE site for Denali National Park and Preserve and was established in September 2001 to evaluate the long-range transport of pollution into the Park from the south. The elementary school experiences relatively little traffic during the day, about 4 buses and 50 automobiles. The school is closed June through August. This site was selected because it has year-round access to power, is relatively open, and is not directly impacted by local sources.

IMPROVE monitoring data have been recorded at the Denali Headquarters IMPROVE site from March of 1988 to present. The IMPROVE monitor near the Park's headquarters was the original IMPROVE site. Due to topographical barriers, such as the Alaska Range, it was determined that the headquarters site was not adequately representative of the entire Class I area. Therefore, Trapper Creek, just outside of the park's southern boundary, was chosen as a second site for an IMPROVE monitor and is the official Denali IMPROVE site as of September 10, 2001. The headquarters site is now the protocol site. A Clean Air Status and Trends Network (CASTNet) monitor is located near the Denali Headquarters IMPROVE site.

Simeonof Wilderness Area

Simeonof Wilderness Area comprises 25,141 acres located in the Aleutian Chain, 58 miles from the mainland. It is one of 30 islands that make up the Shumagin Group on the western edge of the Gulf of Alaska. Access to Simeonof is difficult due to its remoteness and the unpredictable weather. Winds are mostly from the north and northwest as part of the midlatitude westerlies. Occasionally winds from Asia blow in from the west. The island is isolated and the closest air pollution sources are marine traffic in the Gulf of Alaska and the community of Sand Point.

The Fish and Wildlife Service placed an IMPROVE air monitor in the community of Sand Point to represent the wilderness area. The community is on a nearby, more accessible island approximately 60 miles north west of the Simeonof Wilderness Area. The monitor has been on-line since September 2001. The location was selected to provide representative data for regional haze conditions at the wilderness area.

Tuxedni National Wildlife Refuge

Tuxedni National Wildlife Refuge is located on a fairly isolated pair of islands in Tuxedni Bay, Cook Inlet in Southcentral Alaska. There is little human use of Tuxedni except for a few kayakers and some backpackers. There is an old cannery built near Snug Harbor on Chisik Island which is not part of the wilderness area; however it is a jumping off point for ecotourists staying at Snug Harbor arriving by boat or plane. The owners of the land have a commercial fishing permit as do many Cook Inlet fishermen. Set nets are installed around the perimeter of the island and in Tuxedni Bay during fishing season.

Along with commercial fishing, Cook Inlet has reserves of gas and oil that are currently under development. Gas fields are located at the Kenai area and farther north. The inlet produces 30,000 barrels of oil a day and 485 million cubic feet of gas per day. Pipelines run from Kenai to the northeast and northeast along the western shore of Cook Inlet starting in Redoubt Bay. The offshore drilling is located north of Nikiski and the West McArthur River. All of the oil is refined at the Nikiski refinery and the Kenai Tesoro refinery for use in Alaska and overseas.

The Fish and Wildlife Service installed an IMPROVE monitor near Lake Clark National Park to represent conditions at Tuxedni Wilderness Area. This site is on the west side of Cook Inlet, approximately 5 miles from the Tuxedni Wilderness Area. The site was operational as of December 18, 2001, and represents regional haze conditions for the wilderness area.

Bering Sea Wilderness Area

The Bering Sea Wilderness Area is located off the coast of Alaska about 350 miles southwest of Nome. Hall Island is at the northern tip of the larger St Matthew Island.

The Bering Sea Wilderness Area had a DELTA-DRUM sampler placed on it during a field visit in 2002. However, difficulties were encountered with the power supply for the sampler and no valid data are available from that effort. No IMPROVE monitoring is currently planned for the Bering Sea Wilderness Area because of its inaccessibility.

Monitoring data and additional information for the Alaskan IMPROVE sites are available from the EPA website, http://vista.cira.colostate.edu/improve .

Additional Monitoring Considerations

DEC published a final study report for the Regional Haze Trans-boundary Monitoring project in July 2012.
(http://www.dec.state.ak.us/air/am/Haze%20report/Final%20Regional%20Haze%20Trans-Boundary%20Monitoring%20Project.pdf)
One of the driving factors for the study was the quantitative evaluation of foreign contribution to local air quality impacts. While long-range transport of pollutants was observed and documented through various measurement techniques, DEC was unable to quantify international source contribution even as a whole. Current sampling methods do not provide enough time resolution to adequately document short events lasting only a few days i.e., the IMPROVE sampling schedule misses 2/3 of the year because samplers operate every third day. DRUM samplers which operate on a semi-continuous basis i.e., collecting 3-hour samples, initially seemed a viable method to collect year-round data and provide a comparison to the IMPROVE chemical analysis. Even if all the other problems encountered with operating the DRUM samplers in a remote field setting could be overcome, a reliable quantitative comparison to the IMPROVE data set is not possible given the low mass loading on the DRUM sampling strips combined with uncertainty for start and end hours.

DELTA-DRUM Samplers have been used at several sites in Alaska for relatively short periods. Researchers have unsuccessfully modified these samplers for remote winter use in Denali Park. Drum samplers were set up at the Denali and Trapper Creek sites as well as in McGrath and Lake Minchumina in February and March 2008. They experienced numerous mechanical and pump problems due to severe winter conditions and proved to be too problematic. These samplers operated intermittently between February/March 2006 and April 2009, resulting in very little usable data.

DEC still has concerns about the location of the Denali headquarters IMPROVE site as being representative of the entire Class I area. The Denali Headquarters IMPROVE site is located within the area of most heavy use and development and, thus, may not be representative of the pristine wilderness that makes up the remainder of the park lands. Lake Minchumina was clearly the cleanest site. An argument could be made that most of the 6 million acres of DNPP best resemble Lake Minchumina with its current 13 residents compared to Denali headquarters or Trapper Creek which see nearly a half a million visitors per year. Most of the park visitors (432,301 in 2008), and DNPP staff (145 permanent, 290 summer seasonal) and Talkeetna staff (10 permanent, approximately 20 summer seasonal) are concentrated around DNPP headquarters (personal communication Blakesley 2012, June 6; DNPP, 2012). Traffic is mostly concentrated on the main highway and the single dirt road through the wilderness area (DNPP, 2012).

The question that still needs to be answered is whether or not the Lake Minchumina site is more representative of the entire park than the two existing IMPROVE sites at Denali Headquarters and Trapper Creek. Before a final decision for relocation would be made, additional studies should be conducted that integrate meteorological observations with aerosol concentrations more quantitatively than was possible for this study analysis. As DEC continues to implement its Regional Haze plan and performs required updates in future years, the experience and data gained through this study can be used to inform the development and planning for new monitoring efforts that may provide additional insight into aerosol impacts in Alaska's Class I areas. Given the vast, remote areas of Alaska, the challenge remains to develop air monitoring approaches that can be successfully operated in the State's wilderness areas.

Future studies will use more robust sampling equipment for long term monitoring. Because of the remoteness of Alaska's Class I sites, DEC will most likely explore other sampling equipment for regulatory monitoring to demonstrate compliance with the Regional Haze Rule glide-path. As the concentrations of anthropogenic aerosols decreases toward background it will become more difficult to monitor successfully in the future without advances in monitoring instrumentation and pump and power technologies.

APPENDIX E: NAAQS SUMMARY TABLES

Alaska Monitoring NAAQS Summary for $PM_{2.5}$ as µg/m^3 at Local Conditions NAAQS 35 µg/m^3 (24-Hr, 98th percentile, average over 3 years) NAAQS 15 µg/m^3 (Annual mean, averaged over 3 years)											
		98th Percentile 24-hour Mean				**Weighted Annual Mean**				**2013-2011 Design Value**	
$PM_{2.5}$ Monitoring Sites	**Site ID**	**2013**	**2012**	**2011**		**2013**	**2012**	**2011**		**24-hr**	**Annual**
The Garden Site (MOA)	02-020-0018	15.7	28.4	17.3		4.9	6.6	5.2		20	5.6
Parkgate Site (MOA)	02-020-1004	15.0	17.9	15.7		5.0	5.3	4.6		16	5.0
The Butte Site (Mat-Su Valley)	02-170-0008	27.9	33.4	30.2		6.4	5.9	6.4		31	6.3
Palmer Site (Mat-Su Valley)	02-170-0012	11.1	13.7	9.1		3.2	4.2	4.1		11	3.8
Wasilla Site (Mat-Su Valley)	02-170-0013	16.0	22.8	15.1		4.0	5.7	6.3		18	5.3
State Office Building (FNSB)	02-090-0010	36.3	49.6	38.0		10.6	10.7	10.7		41	10.7
NCORE Site (FNSB)	02-090-0034	36.2	50.0	33.1		10.5	11.3	10.4		40	10.7
North Pole Fire #3 (FNSB)	02-090-0035	121.6	158.4	ND		29.1	16.8	ND		NC	NC
Floyd Dryden Site (Juneau)	02-110-0004	22.7	23.5	24.8		5.9	6.4	7.2		24	6.5
Soldotna Site (Kenai Peninsula Borough)	02-122-0008	8.3*	7.4	8.2*		0.9*	1.0	2.9*		NC	NC

ND – No data available, the site was not installed until March 2012.
* Annual values did not meet data completeness criteria, as a result the 3-year design values were not calculated (NC)
NA – not applicable, design values calculations are based on 3 years of complete data

Alaska Monitoring NAAQS Summary for PM_{10} as µg/m³ at STP

NAAQS 150 µg/m³ (Not to be exceeded more than once per year on average over 3 years)

PM_{10} Monitoring Sites	Site ID	2013			2012			2011		
		Exceedances	1st Max 24-hr	2nd Max 24-hr	Exceedances	1st Max 24-hr	2nd Max 24-hr	Exceedances	1st Max 24-hr	2nd Max 24-hr
The Garden Site (MOA)	02-020-0018	0	40	34	0	59	53	0	39	36
Tudor Road Site (MOA)	02-020-0044	1	256	120	0	120	115	0	129	117
Parkgate Site (MOA)	02-020-1004	1	174	78	0	81	77	0	95	62
NCORE (FNSB)	02-090-0034	0	75	72	0	95	83	0	64	52
Butte Site (Mat-Su Valley)	02-170-0008	0	29	26	0	113	81	0	34	34
Palmer Site (Mat-Su Valley)	02-170-0012	0	113	94	0	152	121	2	214	174
Wasilla Site (Mat-Su Valley)	02-170-0013	0	78	63	0	120	109	0	NA	NA
Floyd Dryden Site (Juneau)	02-110-0004	0	33	24	0	24	19	0	24	21
Soldotna Site (Kenai Peninsula Borough)	02-122-0008	0	84	68	0	131	108	NA	NA	NA

NA – data not available

Alaska Monitoring NAAQS Summary for PM_{10} as µg/m^3 at STP 5–Year Arithmetic mean for 2009 through 2013 as related to Limited Maintenance Plan compliance with the annual critical design value (CDV) of 40 µg/m^3		
PM_{10} Monitoring Sites	**Site ID**	**2009 through 2013 5- year Arithmetic Mean (µg/m^3)**
Parkgate Site (MOA)	02-020-1004	15
Floyd Dryden Site (Juneau)	02-110-0004	8

Alaska Monitoring NAAQS Summary for CO as ppm

NAAQS 9 ppm as 8-Hour Mean (Not to be exceeded more than once per year)
NAAQS 35 ppm as 1-Hour Mean (Not to be exceeded more than once per year)

CO Monitoring Sites	Site ID	2013			2012			2011		
		Exceedances	1st Max 8-hour	2nd Max 8-hour	Exceedances	1st Max 8-hour	2nd Max 8-hour	Exceedances	1st Max 8-hour	2nd Max 8-hour
The Garden Site (MOA)	02-020-0018	0	3.4	3.1	0	4.4	4.3	0	3.9	3.6
Turnagain Site (MOA)	02-020-0048	0	4.5	4.0	0	6.6	5.5	0	4.4	4.2
Old Post Office (FNSB)	02-090-0002	0	3.6	3.2	0	6.8	6.7	0	6.9	5.4
NCORE (FNSB)	02-090-0034	0	2.8	2.7	0	2.4	2.1	0	3.0	2.6

Alaska Monitoring NAAQS Summary for SO_2 as ppb

NAAQS 75 ppb (99th percentile of 1-hour daily maximum concentration averaged over 3 years)

SO_2 Monitoring Site	Site ID	2013		2012		2011		3-yrs Design Value
		99th Percentile	Completed Quarters	99th Percentile	Completed Quarters	99th Percentile	Completed Quarters	
NCORE (FNSB)	02-090-0034	37	4	49	4	44*	1	41

Alaska Monitoring NAAQS Summary for O_3 as ppm NAAQS 0.075 ppm 8-hour (Annual 4th highest daily maximum 8-hr concentrations averaged over 3 years)											
O_3 Monitoring Sites	Site ID	2013			2012			2011			3-Years	
		Valid Days	Percent Compl	4th Max	Valid Days	Percent Compl	4th Max	Valid Days	Percent Compl	4th Max	Percent Compl	Design Value
Wasilla Site (Mat-Su Valley)	02-170-0013	NA	NA	NA	143	67	0.048*	167	78	0.049	NC	NC
NCORE (FNSB)	02-090-0034	209	98	0.048	197	92	0.048	85	40*	0.035	NC	NC

* Annual values did not meet data completeness criteria, as a result the design values were not calculated (NC).
NA – not applicable, design values calculations are based on 3 years of complete data

Alaska Department of Environmental Conservation

Amendments to:
State Air Quality Control Plan

Vol. III: Appendix III.D.5.6

{Appendix to Volume II. Analysis of Problems, Control Actions; Section III. Area-wide Pollutant Control Program; D. Particulate Matter; 5. Fairbanks North Star Borough PM2.5 Control Plan}

Adopted

December 24, 2014

Bill Walker
Governor

Larry Hartig
Commissioner

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APPENDIX III.D.5.6

EMISSIONS INVENTORY

INTRODUCTION

This technical appendix provides detailed documentation of the data sources, issues considered and methodologies and workflow applied in developing the baseline emission inventories developed to support the episodic attainment modeling in the Fairbanks $PM_{2.5}$ SIP. The intent of this documentation is to explicitly describe the approaches used in calculating episodic emissions. Thus, the documentation is organized by source sector as follows:

- Episodic Point Sources;
- Home Heating Area Sources;
- Other Area Sources;
- On-Road Mobile Sources; and
- Non-Road Mobile Sources.

(Biogenic emissions do not occur in Fairbanks during the snow and ice-bound winter $PM_{2.5}$ season.)

For all inventory sectors, episodic modeling emissions were generally calculated using a "bottom-up" approach that relied heavily on an exhaustive set of locally measured data used to support the emission estimates.

Within the Home Heating sector, separate sections are provided that detail key underlying data sources and components of the approach used to estimate episodic home heating emissions, given their importance within the entire inventory as follows:

- Development of Energy Model – describes local instrumented data collection and analysis used to develop a home heating energy demand model calibrated to episodic wintertime conditions in Fairbanks;

- Residential Surveys – documents the structure, content and approach used to collect key activity, source mix and behavior pattern data in a series of home heating surveys of locally sampled residential households;

- Fairbanks Wood Energy and Moisture Content – explains the data sources used to identify the local mix and energy content of wood species used in home heating and the methods used to account for the effect of wood moisture content on emissions;

- OMNI and AP-42 Emission Factors – discusses the emission factors used to estimate home heating emissions in Fairbanks by device type and includes factors developed from laboratory testing local heating devices and AP-42-based rates; and

- Emission Calculation Details – explains how each of the data sources and upstream methods were combined to estimate gridded hourly estimates of home heating emissions.

EPISODIC POINT SOURCE DATA

Given the potential for strong seasonal variations in facility activity and demand point source emissions to support the episodic modeling were developed on a day- and hour-specific basis for each of the key point source facilities within the modeling domain. This section of the technical appendix describes how episodic activity data were collected by ADEC and emission estimates calculated for these point sources. It also explains how these data were reviewed for quality assurance before being loaded into the SIP modeling inventory.

BASE YEAR EPISODIC POINT SOURCE DATA

For the 2008 base year SIP inventory, ADEC 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 initially included in the query to ensure that facilities within the non-attainment area just below the 100 TPY threshold were also identified to determine whether their emission levels might warrant treatment and individual stationary point sources within the SIP model inventory.

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 from development of episodic emissions. These facilities were excluded because of their remoteness relative to Fairbanks (all are between 55 and 78 miles away)[1] 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) and were excluded from treatment as individual episodic point sources because they were either 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 5.6-1. 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 5.6-1 are located within the non-attainment area.

[1] Individual point source plume modeling conducted by ADEC in support of the SIP using the CALPUFF model found that under the episodic meteorological conditions, emissions from facilities located outside the Fairbanks PM2.5 non-attainment area exhibited negligible contributions to ambient $PM_{2.5}$ concentrations in the area.

Table 5.6-1 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 during winter, a by-product from Flint Hills Refinery.

As noted in Table 5.6-1, some of the equipment is not normally operated during wintertime modeling episodes. This infrequently operated equipment includes backup boilers and emergency generators.

In December 2010, ADEC sent letters of request and spreadsheet templates to each of the eight point source facilities listed in Table 5.6-1, requesting additional actual day- and hour-specific activity and emissions data from each facility (as available) covering the two 2008 historical modeling episodes:

- Episode 1 (E1) – January 23 through February 10, 2008; and
- Episode 2 (E2) – November 2 through November 17, 2008.

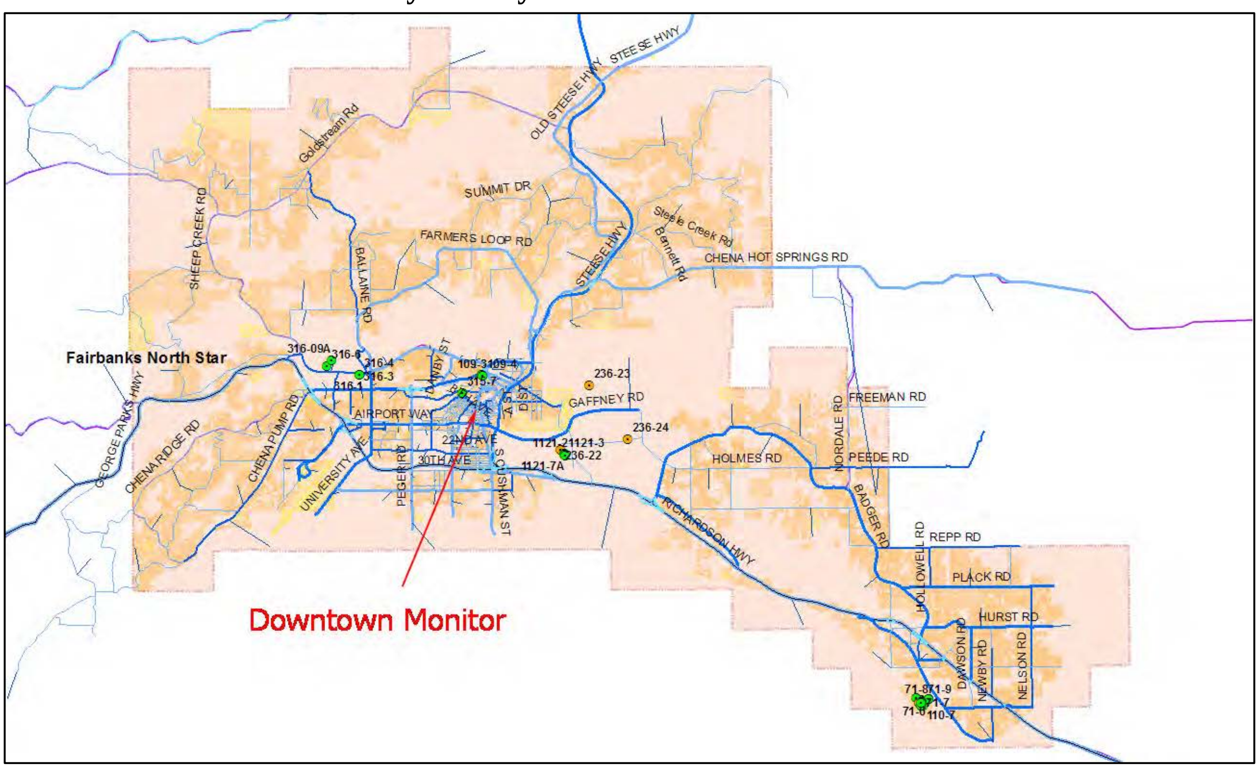
The spreadsheet template contained individual sheets organized in a structure similar to that use to collect and submit stationary point source data to EPA under National Emission Inventory (NEI) reporting requirements. Information was requested for both combustion and fugitive sources. Requested data elements included emission units, stack parameters (height, diameter, exit temperature and velocity/flow rate), release points (location coordinates), control devices (as applicable), seasonal and diurnal fuel properties and throughput.

If available (e.g. through continuous emissions monitoring systems) facilities were also directed to submit additional spreadsheets with day and hour-specific data for the two historical modeling episodes.

Episodic 2008 actual data were provided by seven of the eight facilities listed earlier in Table 5.6-1. (Episodic data were not provided for Fort Wainwright (Facility ID=236) since as its backup diesel generators and boilers were not in operation during the two 2008 modeling episodes as noted in Table 5.6-1.) The facilities provided fuel use, sulfur content, emission factor, and/or emissions data. The pollutants of interest included $PM_{2.5}$, sulfur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOC).

Figure 5.6-1 shows the locations of each of the point sources contained within the $PM_{2.5}$ nonattainment area (the tan shaded area), by facility ID and stack ID. The green dots represent locations of combustion point sources while the orange dots signify fugitive VOC sources. The location of the downtown ambient $PM_{2.5}$ monitor is also shown in Figure 5.6-1.

Figure 5.6-1
Location of Point Sources by Facility ID Within Fairbanks $PM_{2.5}$ Non-Attainment Area



QUALITY ASSURANCE REVIEW

ADEC's contractor, Sierra Research, Inc. (Sierra), then assembled and reviewed the submitted data 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 NO_x and VOC emission rates from AP-42[2] based emission factors (where fuel use data were explicitly provided) or from fuel-specific emission factor ratios.

The actual episodic data obtained from each facility are summarized below. Any corrections made to the data during the review are specifically noted.

Flint Hills Refinery (#71) - The Flint Hills Refinery (FHR) provided ADEC with hourly emissions data for $PM_{2.5}$/ SO_2/NO_x/ VOC for five release points encompassing 12 emission sources. Flint Hills Refinery did not differentiate the hourly emissions among the underlying emission sources. Flint Hills Refinery did not provide the underlying fuel usage rates, process throughput rates, or the emission factors associated with these emissions. Flint Hills Refinery did not provide the basis for the emissions data; it only provided the hourly emissions. Emissions from one of the four release points – the flare – are insignificant compared to the emissions from the four release points. Flint Hills Refinery did not provide stack temperature, stack flow rate, or stack velocity data for the flare.

GVEA Zehnder Power Plant (#109) - GVEA provided ADEC with hourly fuel consumption and PM/SO_2 emissions data for two liquid-fired gas turbines and two liquid fired generators. The gas turbines (Units 1/2) burn HAGO/Jet A. GVEA calculated hourly PM/SO_2 emissions from the hourly fuel usage and emission factors. Sierra similarly calculated hourly NO_x/VOC emissions from the hourly fuel usage and emission factors.

For Units 1/2, GVEA used a source test-derived filterable PM emission factor; Sierra assumed that PM comprised 100% $PM_{2.5}$ since AP-42 does not distinguish PM emissions by particle size. Sierra further assumed that the condensable PM fraction was negligible compared to the filterable PM fraction. GVEA derived the HAGO/Jet A SO_2 emission factors from the averaged measured HAGO/Jet A sulfur contents and HAGO/Jet A higher heating values (HHV). Sierra obtained the NO_x/VOC emission factors for an uncontrolled gas turbine from Tables 3.1-1 and 3.1-2a, respectively, of AP-42 (April 2000).

For the generators (Units 3/4), GVEA obtained the $PM_{2.5}$ emission factor from Table 3.4-2 of AP-42 (October 1996). GVEA derived the diesel SO_2 emission factor from the averaged measured Jet A sulfur content and jet A HHV. Sierra obtained the NO_x/VOC emission factors for an uncontrolled engine from Table 3.4-1 of AP-42 (October 1996). Sierra corrected some

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

errors it discovered while reviewing GVEA's calculations. Units 3/4 SO_2 emissions were overstated by a factor of 100 because the fuel sulfur content was not divided by 100 in the calculation. Unit 4 SO_2 emissions during November were further overstated. The combined emissions from Units 3/4 were calculated rather than apportioning the fraction attributable to Unit 4. Emissions from the two generators are insignificant compared to the emissions from the two gas turbines. GVEA did not provide stack temperature, stack flow rate, or stack velocity data for the generators.

GVEA North Pole Power Plant (#110) **-** GVEA provided ADEC with hourly fuel consumption and PM/SO_2 emissions data for three liquid-fired gas turbines comprising five release points (two turbines each discharge to two separate stacks). Units 1/2 burn HAGO while Unit 5 burns a combination of naphtha and Jet A. GVEA calculated hourly PM/SO_2 emissions from the hourly fuel usage and emission factors. Sierra similarly calculated hourly NO_x/VOC emissions from the hourly fuel usage and emission factors.

For Units 1/2, GVEA used a source test-derived PM_{10} emission factor; Sierra assumed that PM_{10} comprised 100% $PM_{2.5}$ since AP-42 does not distinguish PM emissions by particle size. GVEA derived the SO_2 from the averaged measured HAGO sulfur content and HAGO HHV. Sierra obtained the NO_x/VOC emission factors for an uncontrolled gas turbine from Tables 3.1-1 and 3.1-2a, respectively, of AP-42 (April 2000). Sierra corrected an error it discovered while reviewing GVEA's calculations. Units 1/2 emissions were inadvertently calculated using the jet A HHV rather than the HAGO HHV.

For Unit 5, GVEA obtained the PM emission factors (filterable and condensable) from Table 3.1-2a of AP-42 (April 2000); Sierra assumed that PM comprised 100% $PM_{2.5}$ since AP-42 does not distinguish PM emissions by particle size. The AP-42 PM emission factor used for Unit 5 is over an order of magnitude lower than the source test-derived PM_{10} emission factor used for Units 1/2. GVEA derived the naphtha/Jet A SO_2 emission factors from the averaged measured naphtha/Jet A sulfur contents and naphtha/Jet A HHVs. The naphtha/Jet A SO_2 emission factors used for Unit 5 are nearly an order of magnitude lower than the HAGO SO_2 emission factor used for Unit 5 because the sulfur content of HAGO is much higher than that of naphtha/Jet A. Sierra obtained the NO_x/VOC emission factors for a water injected gas turbine from Tables 3.1-1 and 3.1-2a, respectively, of AP-42 (April 2000).

Eielson Air Force Base (#109) **-** Eielson Air Force Base provided ADEC with combined hourly $PM_{2.5}$ and SO_2 emissions data for six release points, each comprising one coal-fired spreader stoker boiler. Eielson did not differentiate the hourly emissions among the underlying boilers but did provide the underlying hourly steam production rates associated with each boiler. Eielson did not provide the basis for the hourly $PM_{2.5}$ and SO_2 emissions data; it only provided the combined hourly emissions. Sierra allocated hourly $PM_{2.5}$ and SO_2 emissions among the six boilers proportional to hourly steam production relative to the total steam production.

Sierra calculated hourly NO_x and VOC emissions from the hourly $PM_{2.5}$ emissions using the ratio of NO_x/VOC emission factors to an assumed $PM_{2.5}$ emission factor. Sierra obtained the assumed total $PM_{2.5}$ emission factor, representing the sum of filterable and condensable emission factors, for a spreader stoker boiler equipped with a baghouse and firing sub-bituminous coal (or bituminous coal when sub-bituminous coal emissions data were not available) from Tables 1.1-5 and 1.1-9 of AP-42 (September 1998). Sierra obtained the NO_x/VOC emission factors for a water injected gas turbine from Tables 1.1-3 and 1.1-19, respectively, of AP-42 (September 1998).

Emission factors for spreader stoker boilers firing sub-bituminous coal (or bituminous coal when sub-bituminous coal emissions data were not available). Sierra similarly allocated hourly emissions among the six boilers proportional to hourly steam production relative to the total steam production.

Aurora Energy, LLC (#315) **-** Aurora Energy, LLC provided ADEC with hourly average $PM_{2.5}$/SO_2 emissions data, which Aurora derived from daily emissions, for one release point encompassing 4 emission sources (i.e., coal boilers). Aurora did not differentiate the daily emissions among the underlying emission sources. Aurora did not provide the basis for the $PM_{2.5}$/SO_2 emission calculations. Aurora did not provide any hourly fuel usage or steam production data to enable Sierra to allocate daily emissions on an hour basis proportional to hourly plant production.

Aurora also provided Sierra directly with daily coal usage data from which Sierra used emission factors (in lb/mmBTU) to calculate daily NO_x/VOC emissions. Aurora provided Sierra permitted NO_x emission rates and maximum heat input rates for each boiler, from which Sierra derived NO_x emission factors (in lb/mmBTU). Sierra obtained the VOC emission factor for a coal-fired spreader stoker boiler from Table 1.1-19 of AP-42 (September 1998). Since Aurora did not provide any hourly fuel usage or steam production data to enable Sierra to allocate daily emissions on an hour basis proportional to hourly plant production, Sierra calculated the average hourly NO_x /VOC emissions from the daily NO_x /VOC emissions.

University Of Alaska, Fairbanks (#316) **-** The University of Alaska, Fairbanks (UAF) provided ADEC with hourly fuel use data for four boilers – two coal-fired and two oil-fired – comprising four separate release points. UAF subsequently confirmed with Sierra that the fuel oil usage units of measure are actually gallons per minute, though initially reported as gallons per hour. Aurora did not provide hourly emissions data. Sierra calculated hourly $PM_{2.5}$/SO_2/ NO_x /VOC emissions using emission factors and fuel usage. UAF provided fuel sulfur content data and a source test-derived coal $PM_{2.5}$ emission factor. Sierra obtained SO_2/ NO_x /VOC emission factors for overfeed stoker boilers burning sub-bituminous coal from Tables 1.1-3 and 1.1-19 of AP-42 (September 1998). Sierra obtained $PM_{2.5}$/SO_2/ NO_x /VOC emission factors for industrial boilers burning #2 fuel oil from Tables 1.3-1, 1.3-2, and 1.3-3 of AP-32 (May 2010).

Doyon Utilities (#1121) **-** Doyon Utilities provided ADEC with daily emissions data for $PM_{2.5}$ and SO_2 for six release points, each comprising one coal-fired spreader stoker boiler. Doyon did not provide the hourly emissions for each boiler but did provide the underlying hourly steam production rates associated with each boiler. Doyon calculated daily $PM_{2.5}$/SO_2 emissions from the daily coal usage, daily coal sulfur content, and emission factors. Doyon obtained the $PM_{2.5}$/SO_2 emission factors for spreader stoker boilers equipped with a baghouse and firing sub-bituminous coal (or bituminous coal when sub-bituminous coal emissions data were not available) from Tables 1.1-3, 1.1-5, and 1.1-9 of AP-42 (September 1998). Sierra similarly calculated daily NO_x / VOC emissions from the daily coal usage and emission factors. Sierra obtained the NO_x /VOC emission factors for spreader stoker boilers firing sub-bituminous coal from Tables 1.1-3 and 1.1-19 of AP-42 (September 1998). Sierra allocated hourly emissions among the six boilers proportional to hourly steam production relative to the daily steam production.

Doyon was unable to provide hourly steam production data for January 24th. Sierra allocated daily emissions by assuming that the hourly emissions were proportional to the average of the hourly emissions from the preceding and following day (i.e., January 23rd and 25th). Hourly steam production was also missing for Hours 14 through 16 on November 15th. Sierra assumed that hourly steam production for these missing hours equaled the average of the preceding and following hours (Hour 13 and 17).

<u>Cross-Facility Fuel Properties Review</u> – As an additional data validation check, a comparison of key fuel properties across all of the point source facility data was performed. Although fuel property data submitted by facilities were based on actual fuel measurements, the intent was to ensure there were no inadvertent transcription errors in the submitted data by confirming that these data fell within accepted ranges. Table 5.6-2 summarizes the results of sulfur and ash content comparisons by fuel type across all facilities using each fuel.

Table 5.6-2
Comparison of Key Point Source Fuel Properties

Fuel	Sulfur Content (%)	Ash Content (%)
LPG/Natural gas	~0.001	0
Naphtha	0.018 - 0.024	0
Jet A	0.083 - 0.093	0
Coal	0.12 – 0.34	7-15
Distillate Oil	0.39 – 0.44	0
HAGO	0.69 – 0.71	0

<u>Source Coordinates Review</u> – Coordinates for stack/vent release point locations obtained from each facility were also reviewed by Sierra. The transmittal spreadsheets requested latitude and longitude coordinates and the geodetic datum on which they were based for the source release points of each facility.

To validate the source coordinate data submitted by each facility, the latitude/longitude data and datum (when provided) were loaded into GIS software (ArcGIS). As-received coordinates were given based on a combination of WGS84, NAD1983 and NAD1927 datums. Thus the first step in validating the coordinate data consisted of converting them all to a single standardized datum (WGS84) within ArcGIS. WGS84 was chosen since it is the datum upon with the Google Earth mapping utility is based. The unified datum coordinate data were then exported to a “KMZ” spatial data file for plotting and viewing within Google Earth.

Several coordinate inconsistencies were found for one or two of the facilities and were straightforward to visually identify using Google Earth. They generally appeared to be the result of either transcription errors in the latitude/longitude data provided or related to uncertainty about the datum upon which they were based. A list of facility-specific coordinate inconsistencies was prepared for ADEC which was used to follow-up with and obtain corrected data from affected facilities. In one instance, revised location coordinates still did not accurate match comparisons of zoomed in Google Earth views and source locations on a building sketch map. For this instance, it was assumed that the datum with which the coordinates were associated was incorrect and the latitude/longitude coordinates were identified directly from the zoomed in Google Earth view.

Emission Comparisons

Episodic vs. Annual Actual and Permitted Levels - Once the facility data were corrected and validated, a series of emission summaries for each facility were developed comparing emissions across each of the two modeling episodes (from the episodic data) to actual emissions for all of calendar 2008 and annual permitted or PTE levels. (The latter two elements were obtained from DEC’s AirTools permits database system.) Emission levels were converted to an average daily basis, to standardize the comparisons of episodic and annual emissions.

Figure 5.6-2 through Figure 5.6-5 presents these episodic, annual and permitted emissions of $PM_{2.5}$, SO_2, NO_x, and VOC, respectively, for each source facility. (Episodic NH_3 data were not available.) Within each figure, four sets of daily average emissions (in tons/day) are plotted for each facility, as described below.

1. *2008 E1 Avg* – Episode 1 (Jan. 23 - Feb 10, 2008) average daily actual emissions
2. *2008 E2 Avg* – Episode 2 (Nov.2 – Nov. 17, 2008) average daily actual emissions
3. *2008 Actual* – 2008 actual annual average daily emissions (from DEC database)
4. *PTE* – Allowable or permitted annual Potential to Emit (PTE) levels, expressed on an average daily basis (from DEC database)

In comparing allowable (PTE) limits to the actual emissions in this set of figures, one should compare only actual annual emissions (green bars) to the PTE limits (purple bars) since all the data are plotted on an average daily basis. In other words, the fact that GVEP NP Episode 1 average daily emissions in Figure 5.6-2 (blue bar) are higher than the PTE level (purple bar) does not indicate the PTE limit was exceeded since it is an annual, rather than daily limit.

As seen in Figure 5.6-2, significant differences exist for certain facilities between actual daily average $PM_{2.5}$ emissions during the winter modeling episodes and permitted (i.e., PTE) average daily emission levels. Moreover, the difference in average actual daily emissions also varied significantly between modeling episodes (and compared to actual annual average emissions) for specific facilities, notably the GVEA North Pole (NP) power plant.

Figure 5.6-2
2008 $PM_{2.5}$ Episodic, Actual Annual and PTE Point Source-Emissions (tons/day)

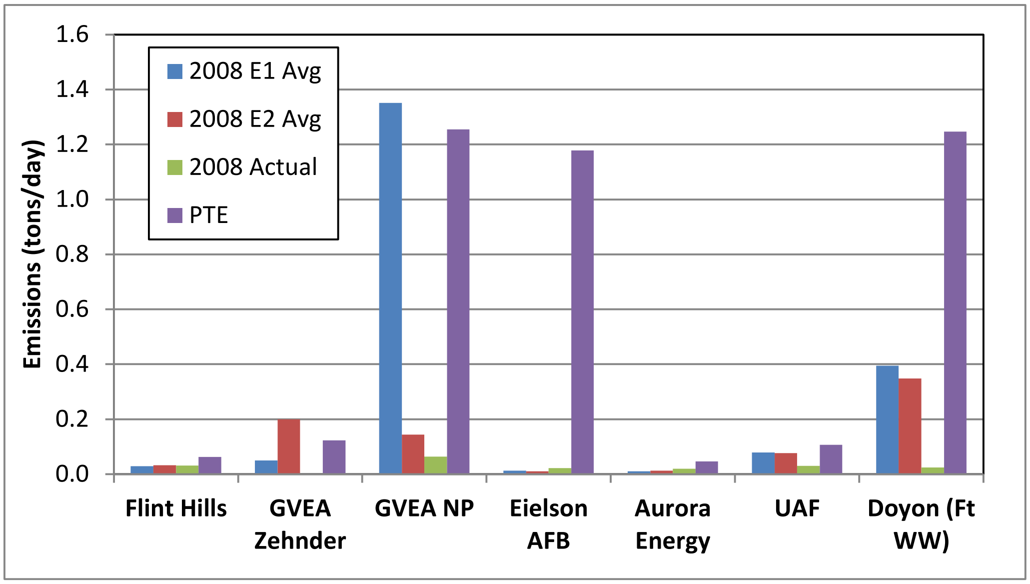


Figure 5.6-3
2008 SO_2 Episodic, Actual Annual and PTE Point Source-Emissions (tons/day)

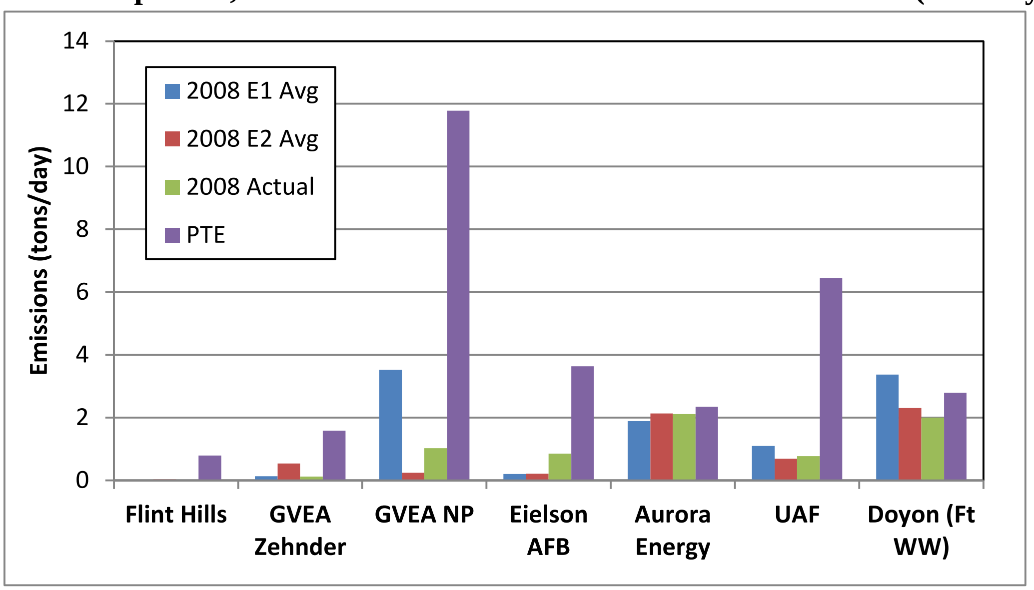


Figure 5.6-3 through Figure 5.6-5 show similar comparisons for the precursor pollutants.

In comparing the facility-specific daily emission averages across this series of plots, it is noted that the PTE emissions represent allowable limits based on operating permits in place in the 2008

Figure 5.6-4
2008 NO_x Episodic, Actual Annual and PTE Point Source-Emissions (tons/day)

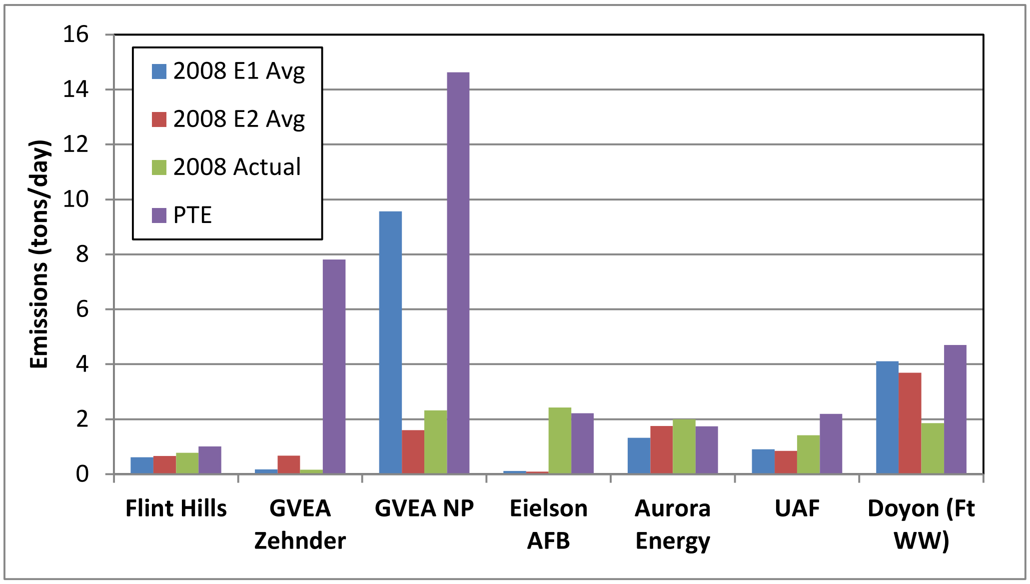
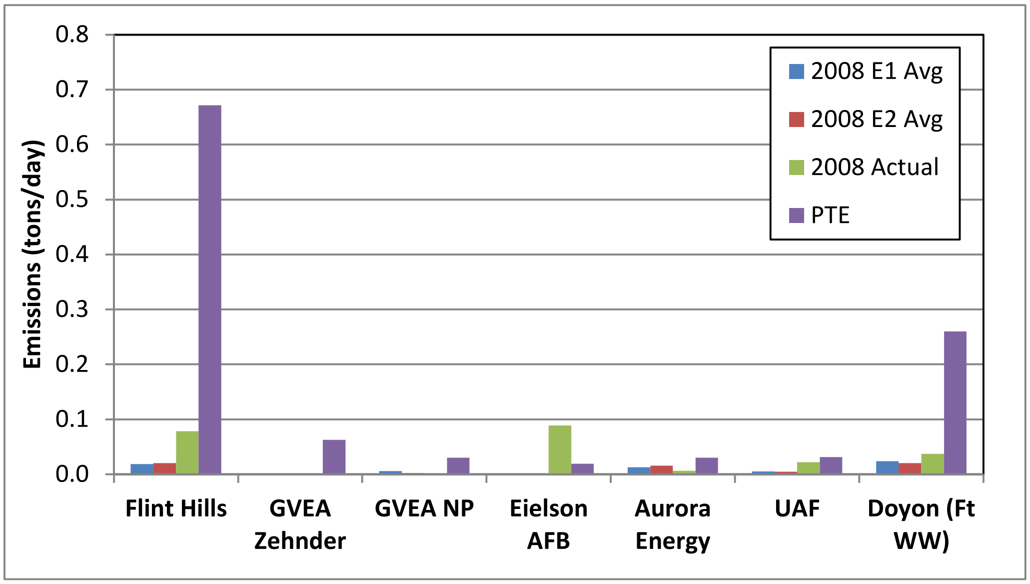


Figure 5.6-5
2008 VOC Episodic, Actual Annual and PTE Point Source-Emissions (tons/day)



baseline year that continue through 2014 with exceptions at UAF[3] and Flint Hills[4] that were assumed to not affect allowable emissions in the projected 2015 inventories.

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[3] UAF received a construction permit (under Title I of the CAA) in April 2014 for replacement of its two existing coil-fired boilers with new dual fuel-fired circulating fluidized bed (CFB)

In addition, the episodic actual emissions for these point sources in the modeling inventory are represented on a day- and hour-specific basis. The E1 and E2 emission levels shown in the plots are averages compiled from the day- and hour-specific emissions across each modeling episode.

Hourly Emissions – In addition to examining episodic, annual and PTE emissions, comparisons of hourly emissions averaged across all days in each episode were also developed for each facility.

Figure 5.6-6 and Figure 5.6-7 compare average hourly $PM_{2.5}$ emissions for each facility in Episode 1 and Episode 2, respectively. As seen in these two figures, the hourly $PM_{2.5}$ emission profiles vary both by facility within an episode, as well as across each episode for some facilities. The two GVEA facilities show significant variation in hourly average emissions. As seen in Figure 5.6-6 hourly $PM_{2.5}$ emissions at GVEA North Pole (GVEA-NP) vary by nearly a factor of ten, with emissions highest from 10 am through around 10 pm before dropping significantly. The GVEA-Zehnder emissions also vary, but appear more muted when plotted on the same scale because emissions for that facility during Episode 1 are much lower than at GVEA-NP. In contrast, Figure 5.6-7 shows that GVEA-Zehnder $PM_{2.5}$ hourly emissions vary even more dramatically that GVA-NP during Episode 2. Hourly $PM_{2.5}$ emissions for the other five facilities are much more constant throughout the day.

Figure 5.6-8 and Figure 5.6-9 present similar comparisons across Episodes 1 and 2 for hourly SO_2 emissions. Again, the two GVEA facilities exhibit significant variation in diurnal SO_2 emissions, while emissions for the other facilities are generally flat across each hour of the day.

boilers that will result in modest changes in facility PTE levels. As of the date of this SIP submittal, it was unknown if these boiler replacements would actually occur in 2015. Thus, pre-April 2014 PTE levels were assumed for UAF in 2015.

[4] In the first half of 2014, the Flint Hills Refinery was shut down. Production of both gasoline and other fuel products ended in early summer. The facility's actual and PTE emissions were still applied in the 2015 inventory given uncertainty about the closing/decommissioning schedule for the refinery at the time the inventory was finalized.

Figure 5.6-6
Episode 1 Average Hourly $PM_{2.5}$ Emissions (lb) by Facility

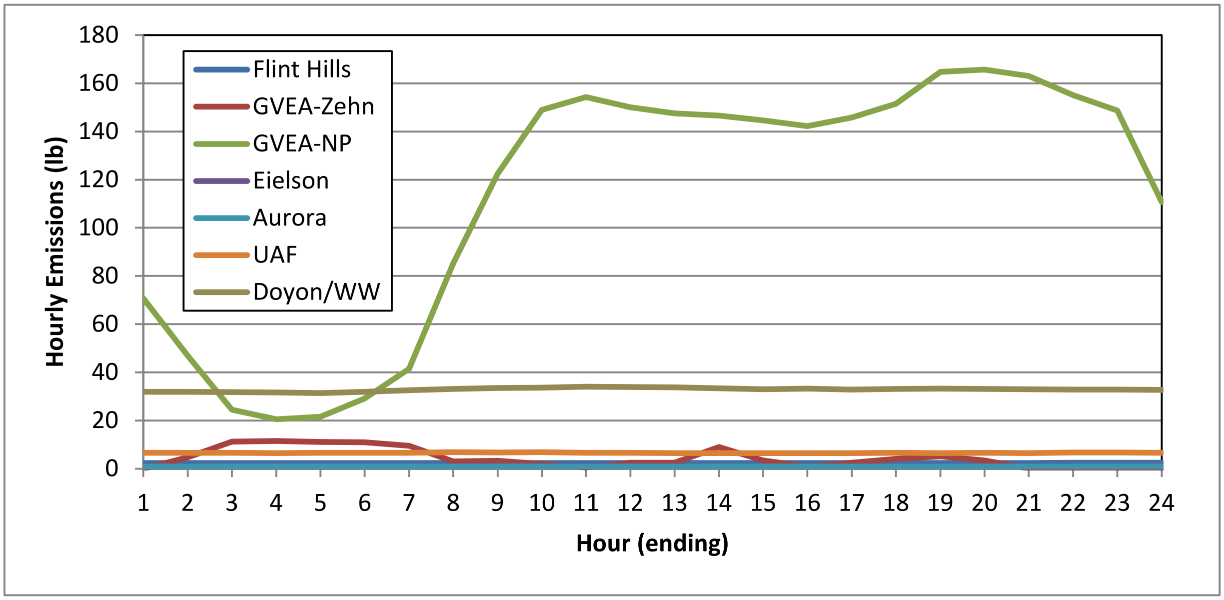


Figure 5.6-7
Episode 2 Average Hourly $PM_{2.5}$ Emissions (lb) by Facility

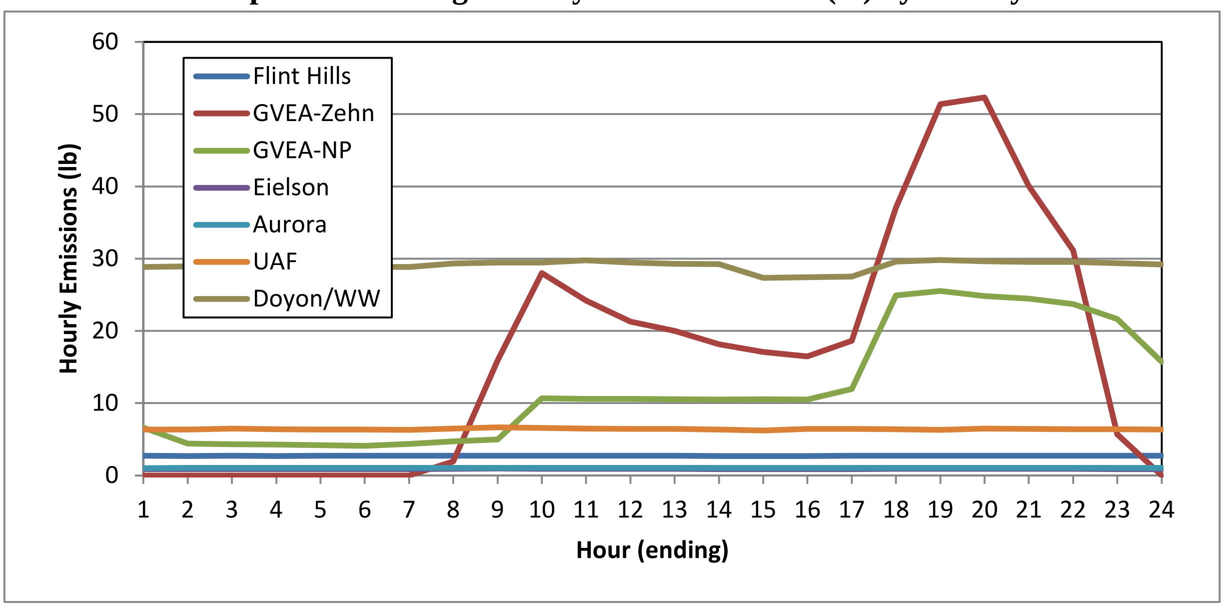


Figure 5.6-8
Episode 1 Average Hourly SO_2 Emissions (lb) by Facility

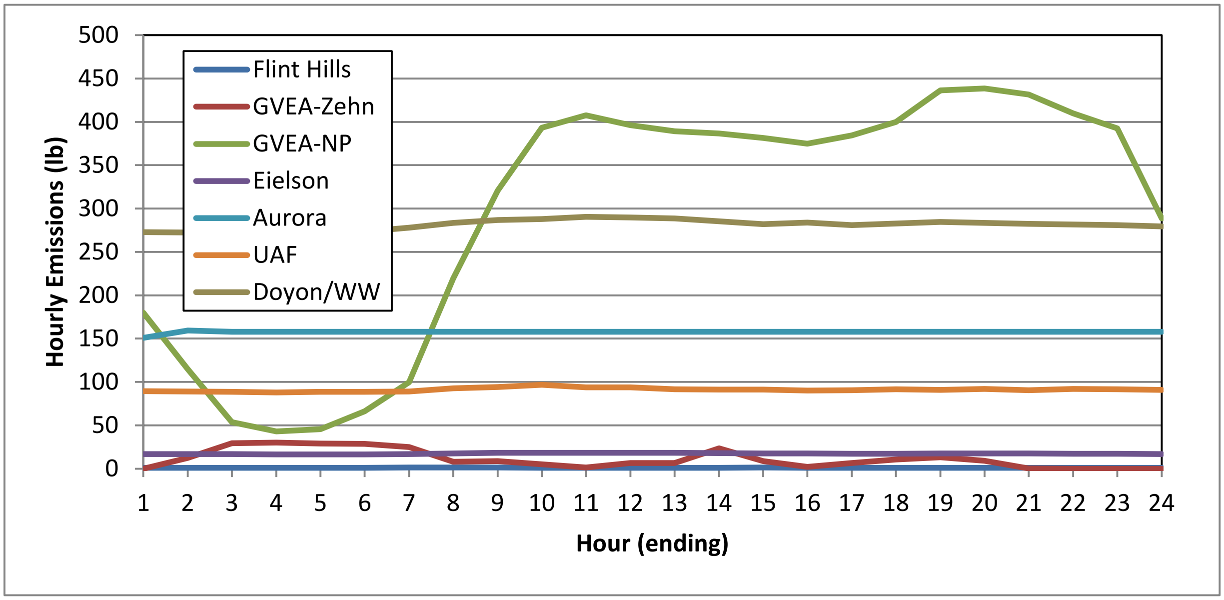
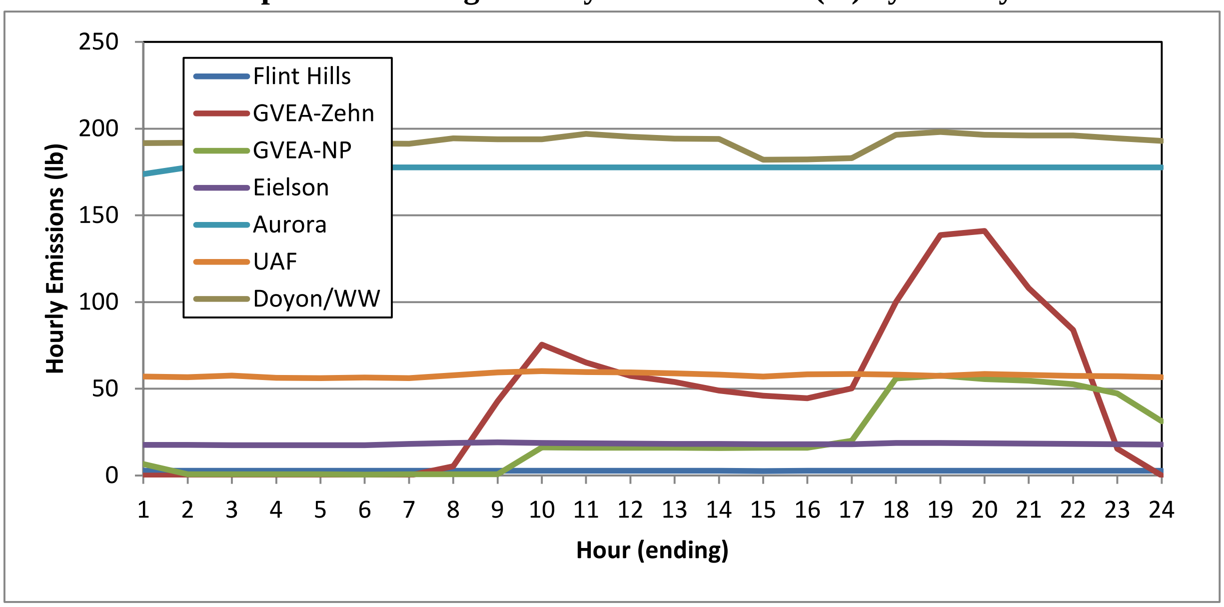


Figure 5.6-9
Episode 2 Average Hourly SO_2 Emissions (lb) by Facility



Projected Baselines

Often, projected baseline emissions for stationary point source facilities are developed based on actual emissions in the baseline year (2008 in this SIP) with activity growth projected using population or employment forecasts or other reasonable growth surrogates, coupled with control factors that reflect effects of emission reductions from phase in or addition of industrial source controls triggered by technology-based regulatory standards (e.g., RACT/BACT[5]) for areas with an existing SIP.

For this Moderate Area SIP, future activity growth for all permitted point sources was held constant at actual 2008 episodic levels. This assumption was made for two reasons:

1. Uncertainty Regarding HAGO Switching - The final SIP inventories were prepared and used in attainment modeling during spring of 2014. In February 2014, Flint Hills publicly announced plans to shut down their refinery in North Pole, with complete decommissioning of the facility expected by the end of 2014. Flint Hills Refinery has been the supplier of the HAGO fuel used during winter by the GVEA North Pole and Zehnder power plants. (HAGO was a refinery by-product than represented a cost-effective fuel for GVEA.) Source test-based emission factors from GVEA burning HAGO and other facilities burning coal or oil indicate that $PM_{2.5}$ emission factors per unit energy for HAGO were roughly an order of magnitude greater than those for coal or oil. With the shutdown of Flint Hills beginning, there was uncertainty at the time the inventories were developed as to what fuel GVEA would substitute for existing HAGO use during winter. Given the magnitude of HAGO emission factors relative to other industrial fuels, actual episodic emissions for GVEA in future years were uncertain.

2. Uncertainty Regarding Population-Driven Effects – Source data collected for the two historical winter 2008 episodes reflected actual activity levels during these two periods. It is unclear how well source throughput or activity correlates with year-to-year changes in population (or ambient temperature). Given the modest 1% per year long-term population growth projected for the area and uncertainty regarding employment growth and the fact that the actual data were collected in 2008 which preceded the economic recession of the last several years, use of a population or employment-based growth surrogate was highly uncertain and not likely to significantly alter future industrial facility activity and emissions.

Given the effect of HAGO use at the GVEA facilities in the 2008 baseline actual point source inventory coupled with the shutdown of Flint Hills Refinery, holding actual emissions constant at 2008 levels likely represent a conservative (i.e. over-stated) estimate of actual emissions in 2015 and 2019.

As explained in Section 5.7, control triggers would not occur until after the submittal of the first-time Moderate Area $PM_{2.5}$ SIP. Thus, the control factor element of the projected baseline point

[5] RACT – Reasonably Available Control Technologies, BACT – Best Available Control Technologies.

source inventories assumes no further control. RACT triggered control requirements may occur in the future, but they are not part of the projected baselines for point sources in this SIP.

Thus, 2008 actual episodic and allowable (PTE) emission levels for the permitted stationary point sources were assumed to apply in the projected baseline inventories.

INVENTORY ASSEMBLY

To support the attainment modeling, the episodic day- and hour-specific emissions for each facility were utilized in modeling actual point source emission cases. Allowable emissions were based on daily (and hourly) averages of annual PTE levels. Rather than assume a constant hourly emission rate, PTE levels for each facility converted to a daily average basis were then apportioned to the average hourly profiles of each facility across both modeling episodes. In other words the episodic average hourly emissions plotted earlier in Figure 5.6-6 through Figure 5.6-9 were converted to relative (fractional) values and then applied to the PTE-based daily average emissions.

In addition, since the PTE levels are totals across all emission units for each facility (e.g., stacks, vents, etc.), allowable emissions were also distributed by emission unit within each facility based on the relative contribution of each unit from actual data averaged across the two historical modeling episodes.

Using these methods, day and hour-specific emissions were developed for both the Actual and Allowable emission cases. For the Actual case, emissions varied by both day and hour based on the historical data. For the Allowable case, emissions were constant for each day and the hourly profile was constant across each day (although it varied by facility).

The day and hour-specific emissions for the Actual and Allowable cases were assembled and formatted for input into the SMOKE emissions pre-processor model as described in Appendix III.D.5.8.

HOME HEATING – DEVELOPMENT OF ENERGY MODEL

OVERVIEW

A spreadsheet-based household space heating "energy model" was developed to support the SIP inventory. This energy model was based on locally-developed home heating energy usage data collected from a stratified sample of residential homes in the Fairbanks area during cold wintertime conditions. The data were collected under a 2011 study[6] conducted by the Cold Climate Research Housing Center (CCHRC).

The primary objective of the study was to collect detailed heating appliance usage pattern data for homes using various combinations of oil and wood heating devices. The approach consisted of instrumentation and collection of fuel usage and device temperature data for a stratified random sample of 30 homes in Fairbanks that used various combinations of oil and wood home heating devices based on pre-study screening surveys. The target sampling matrix consisted of selection of 10 households in each of the following three groups (as identified based on the screening surveys):

1. *Group "O" (Oil Only)* – households heated solely with oil devices that included central oil boilers, oil-fired furnaces or direct-vent (DV) room heating oil devices;

2. *Group "M" (Mixed Oil and Wood)* – households heated with a mixture of oil devices (as listed above) and wood devices that included wood stoves, outdoor wood boilers (OWBs) and fireplaces with wood as the secondary heating source; and

3. *Group "W" (Wood Only/Primary)* – households heated exclusively or primarily with wood-burning devices.

Table 5.6-3 provides a summary of the homes sampled and heating devices within each group. Of the ten "oil" homes, seven used Central Oil boilers, two used direct vent oil heaters, and the tenth used an oil fired furnace. Ten additional homes using a mix of fuel oil and wood were studied. The final ten homes were identified as primarily wood heating. The wood heating systems included seven wood stoves, one fireplace and two outdoor wood boilers. The rated output (in BTU/hour) of each household's oil device is also listed in Table 5.6-3. (For direct vent oil heaters which have 3-4 fuel rate settings, the maximum output is shown.)

The intent of this stratified sample of households was not to necessarily be a representative self-weighing sample of wintertime residential space heating in Fairbanks, but rather to ensure a sufficient range of the most commonly used residential heating devices were sampled and that the range of usage patterns for households with single and multiple heating devices (and their interactions) were adequately measured.

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[6] "Heating Appliance Operation Survey, Phase II Fairbanks, Alaska," Cold Climate Research Housing Center, June 30, 2011.

Table 5.6-3
Home Heating Instrumentation Sample Summary

Residence ID	Heated Area (ft^2)	Oil Appliance	Rated BTU/hour	Wood Appliance
O-01	2,448	Central Boiler	100,000	n/a
O-02	1,500	Central Boiler	147,000	n/a
O-03	2,775	Central Boiler	189,000	n/a
O-04	2,912	Borg Warner Furnace	156,800	n/a
O-05	1,400	Toyo Direct Vent	39,875	n/a
O-06	1,200	Toyo Direct Vent	39,875	n/a
O-07	1,200	Central Boiler	140,000	n/a
O-08	2,200	Central Boiler	189,000	n/a
O-09	2,100	Central Boiler	147,000	n/a
O-10	2,200	Central Boiler	95,200	n/a
M-01	2,464	Central Boiler	147,000	Wood Stove
M-02	2,900	Central Boiler	106,250	Wood Stove
M-03	2,500	Central Boiler	133,000	Wood Stove
M-04	1,770	Central Boiler	95,200	Wood Stove
M-05	1,900	Central Boiler	140,000	Fireplace
M-06	3,000	Central Boiler	252,000	Wood Stove
M-07	1,400	Central Boiler	105,000	Wood Stove
M-08	1,760	Central Boiler	147,000	Wood Stove
M-09	2,600	Central Boiler	118,750	Wood Stove
M-10	2,000	Central Boiler	231,000	Wood Stove
W-01	1,250	Central Boiler	119,000	Wood Stove
W-02	980	Toyo Direct Vent	43,750	Wood Stove
W-03	2,488	OWB preheat	137,500	Outdoor Wood Boiler
W-04	2,100	Central Boiler	140,000	Wood Stove
W-05	5,000	OWB (multi-fuel)	154,000	Central Boiler-oil/wood
W-06	915	Toyo Direct Vent	20,625	Wood Stove
W-07	4,580	Central Boiler	224,000	Outdoor Wood Boiler
W-08	1,400	Toyo Direct Vent	20,625	Wood Stove
W-09	884	Wood Stove only	n/a	Wood Stove
W-10	575	Toyo Direct Vent	20,625	Wood Stove

n/a = Not applicable

The final analysis revealed that during the sampling period, which was characterized by very cold ambient temperatures, three of the homes initially identified as primarily wood burning by the owners actually used oil for more than one-third of the heating energy consumed during the sampling, and could have been characterized as mixed.

Data loggers recording the fraction of time a motor was on were used to monitor central oil boiler and furnace heating appliances (which have a single fuel rate setting). Thermocouples mounted on the surface of the exhaust flue were used to monitor temperatures from wood burning devices and direct vent oil furnaces (which can run at several fuel rate settings). The sampling period extended from early December of 2010 through late February of 2011. Generally speaking, each home was instrumented and fuel usage measurements were collected over a period spanning 6-10 weeks. Written diaries or "logs" of actual fuel use were also kept during the first couple of weeks of sampling in each household. As explained later, these fuel use logs were used to calibrate and validate raw data logger and thermocouple measurements.

Ambient temperature measurements were also collected by CCHRC from a handful of meteorological stations in the Fairbanks area during the winter 2010-2011 sampling period. CCHRC reviewed data from both National Weather Service and Citizen Weather Observer Program sites (CWOP), and selected sites to represent ambient temperatures at each sampled household based on completeness of record and proximity/representativeness of the weather station to each home. CCHRC then temporally merged historical ambient temperature data (recorded every 30 or 60 minutes) from each selected weather station into the appropriate household data file, providing a raw database of hourly oil device operating patterns and wood (and direct vent oil) thermocouple measurements and ambient temperatures.

Sierra then performed a series of data validation and completeness checks on measurements and fuel usage diaries from each sampled household. As discussed later, 4 of the 30 sampled homes were dropped from the analysis because of problems with the measuring equipment as installed in those homes, rendering most if not all of the data for those households invalid.

After reviewing/validating the data, they were analyzed to generate a dataset of household hourly heating energy use (in BTU/hour) by device type and ambient temperature. This winter 2010-2011 energy use dataset was then used to develop a multivariate model of residential household space heating energy use as a function of heated dwelling size, device mix, hour of the day and ambient temperature that could be readily applied within the SIP inventory workflow to generate episodic day-specific and hourly heating energy use and emission estimates. The details of these data analysis and energy model development elements are discussed in the next sub-sections.

Data Processing

Because of the device-specific nature by which usage patterns and fuel measurements were collected, different processing methods were utilized for each type of device. These device-specific methods are described separately below.

Central Oil Boilers/Furnaces – For central oil devices, the process of determining hourly energy usage was straightforward. Data loggers were used to continuously monitor and record the fraction of each hour in the sampling period that the boiler/furnace was operating. Hourly fuel usage rates were determined from the label on the unit (preferred) or from the instruction manual for the particular boiler/furnace model. The energy content (EC) of given volume of fuel was dependent on fuel oil type: 125,000 BTU/gal was used for Fuel Oil #1, while 140,000 BTU/gal was assumed for Fuel Oil #2.

The BTU output for each hour of operation was then simply calculated as:

BTUs/hr = % of Hour Operated × Fuel Usage Rate (gal/hr) × Fuel EC (BTU/gal)

For example, if an oil device burning #2 oil with a fuel usage rate of 0.8 gal/hr was measured to operate for 32.1% of the time during a given hour, the calculated oil energy use for that hour is:

32.1% percent on time × 0.8 gal/hour × 140,000 BTU/gal = 35,952 BTU/hour

Data logger results also included a date and time stamp of the reading. BTU calculations were performed in this manner for all central oil devices and merged into a common database across all households. Results were summarized by residence both as hourly and daily BTUs and inspected for reasonableness.

A log of oil usage was maintained by the homeowners for the duration of the sampling period. At the start and end of sampling and each time a delivery of heating oil was made to their tank, the homeowner used a calibrated dipstick to record the fill level in their oil tank. Tank volume calculations were performed by CCHRC to translate the fill level measurements to volumes and estimates of incremental fuel use between deliveries, although a source of uncertainty for these fill level-based fuel volume estimates occurred for homeowners with underground tanks with unknown capacity and geometry. Notwithstanding this uncertainty for underground tanks, total volume of fuel determined from summing the hourly usage rates was compared to total fuel estimates from storage tank volume logs for consistency/validation.

Wood Burning Devices - Determination of the hourly heat energy obtained from burning wood was less direct. Homeowners recorded the time and weight of all fuel added during an initial “calibration” sampling period. The duration of this period varied from a few days to, in one case, the entire sampling period, but typically averaged 1-2 weeks. The total sampling period within each household was generally two months.

All wood additions were assumed to be White Birch, the predominant wood type in Fairbanks. Using US Forest Products Laboratory tables, at 20% moisture content White Birch is reported to have a weight of 3,179 pounds/cord and an energy content of 20.3 mmBTU/cord, yielding an average energy content of 6,386 BTU/lb.

For the purpose of initially analyzing the wood usage data, the average moisture content of wood from sampled households with wood devices was assumed to be 26.6% based on moisture measurements of wood sampled from of those households conducted by CCHRC. After adjusting for this sampled moisture content, the average energy content used to estimate hourly wood-based energy use was 6,053 BTU/lb. (As explained later, a second wood energy content adjustment was performed when using the energy model developed from these data to calculate

SIP inventory emissions based on specific wood species mix and moisture content data collected to support the inventory estimates.)

This energy content was multiplied by the pounds of fuel added from the homeowner wood diaries to arrive at BTUs added from each wood loading. These fuel-loading BTUs were then totaled across the initial instrumentation period during which wood loading diaries were kept.

A thermocouple was used to measure the flue temperature or surface temperature of the wood stoves from a single fixed location throughout the instrumentation period for each device. The thermocouple logger recorded temperature at 5 minute intervals, producing a value that is an relative indicator of the rate of heat release. Under a simplistic ideal case for distributing energy use across the fuel loading period, the flue temperature would be allowed to rise from ambient during combustion until all of the fuel had been consumed, when the temperature would return to ambient. The temperature rise above ambient in each five minute period during the combustion period would then be summed to provide a surrogate for total energy emitted from that fuel load. The ratio of flue temperatures and wood BTUs would then be used to estimate a rate of energy consumption per cumulative degrees per five minute period using the data logger results.

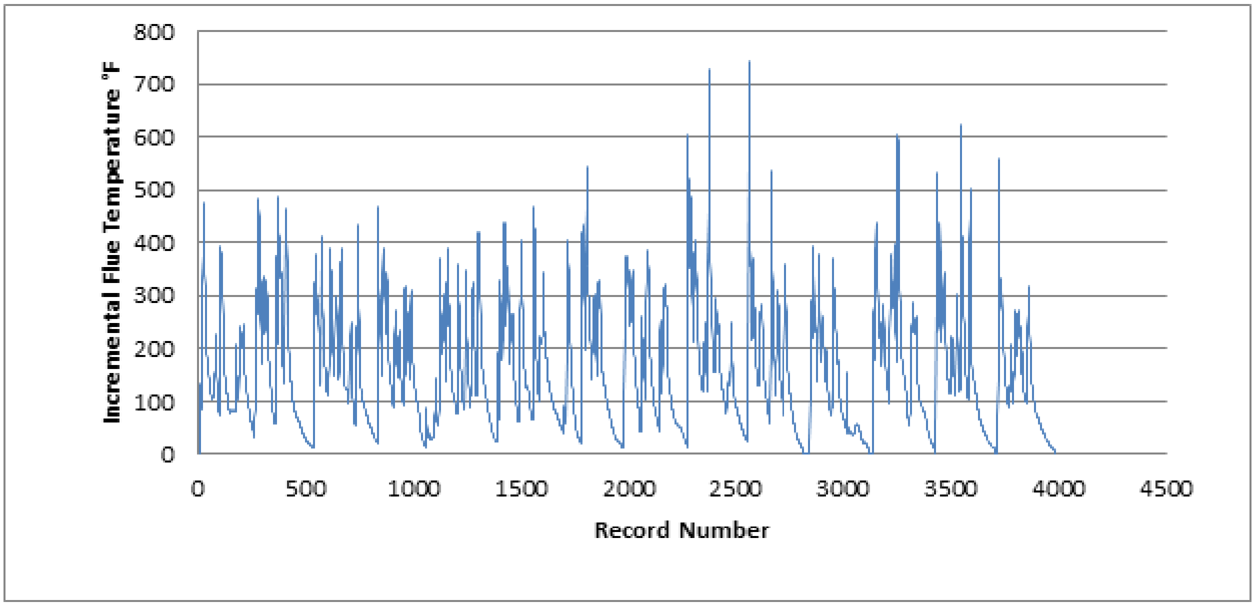
The challenge for wood-burning households was turning the record of wood BTUs added over time into a time series of heat energy (in BTUs) released by the unit. The approach taken was to use the temperature rise recorded by the datalogger to proportion the estimated amount of wood BTUs added to the unit. The temperature rise is the number of degrees Fahrenheit that the recorded temperature is above its baseline. The baseline was determined by locating the lowest temperature level recorded by the datalogger. For indoor devices (stoves, fireplaces) the baseline temperature was based on the indoor room temperature. Outdoor air outdoor air temperatures were used as baselines for outdoor wood boilers (OWBs).

Some households burned wood sporadically. For these, data points could be determined for each burn event, consisting of the wood BTUs added and the total temperature rise over the time period of the burn. Temperatures were recorded every 5 minutes, so the total temperature rise has units of °F × 5 minute interval. For these households, the calibration determined an average factor (°F per BTU) that can be divided into the observed temperature rise in any 5-minute period to determine the BTUs released. The term “BTUs released” refers to the total BTUs estimated to be released by the fire in the time period, consisting of both BTUs that heat the home and BTUs that are lost to the environment.

Other households burned wood nearly continuously and offered no discrete events that could be used to develop an average calibration factor. The same general approach, however, was applied. The cumulative pounds of fuel added (as BTUs of fuel) were plotted against cumulative rise in flue temperature. A linear slope/intercept equation was fit to the data. This resulting equation was then used to estimate the BTUs produced through the entire sample period from the cumulative degree-minutes recorded by the data logger.

Figure 5.6-10 displays the flue temperature observed during the fuel weighing period for one home from the instrumented sample, mixed oil-wood household M-02, which used wood for about 30% of its heating energy. The 4,000 temperature readings made at 5 minute intervals

Figure 5.6-10
Example Wood Stove Fuel Temperature Trace, Household M-02



represent 14 days during which the owner weighed the fuel and recorded the results in a log. Individual temperature readings were adjusted by subtracting the lowest temperature observed in the study period. Thus, as labeled on the vertical axis of Figure 5.6-10, the plotted flue temperatures are incremental values over this baseline minimum temperature.

Figure 5.6-11 displays the cumulative BTU wood additions and cumulative flue degrees for the M-02 woodstove. During this sampling period, a total of 18 wood loadings were made. (Some contained smaller amounts of wood and cannot be discerned from the plotted scales in Figure 5.6-11.) A total of 630 lb of wood were burned across all 18 loadings, equivalent to 3,813,390 BTUs of fuel energy.

The red line in Figure 5.6-11 displays the fitted relationship used to estimate BTUs from flue temperatures recorded during the more extended data collection period for this specific woodstove. Based on the output for this particular stove and the location of the thermocouple during its instrumentation, the relationship between fuel loading data and flue temperatures (i.e. the fitted slope) was found to be 0.190 DegF-Hrs/BTU.

These same analyses of cumulative flue degree-hours vs. wood BTUs were developed for each of the households with valid wood device measurements. Separate fitted "temperature slopes" were developed for the wood devices in each household and were necessitated by the variation in flue temperature response to BTUs calculated from wood loading. This device-to-device variation was the result of difference in where the thermocouple was placed on or near each device, the size/output of the firebox and the general usage pattern of each device (frequent vs. occasional).

Figure 5.6-11
Cumulative Wood Stove BTUs and Flue Degrees, Household M-02

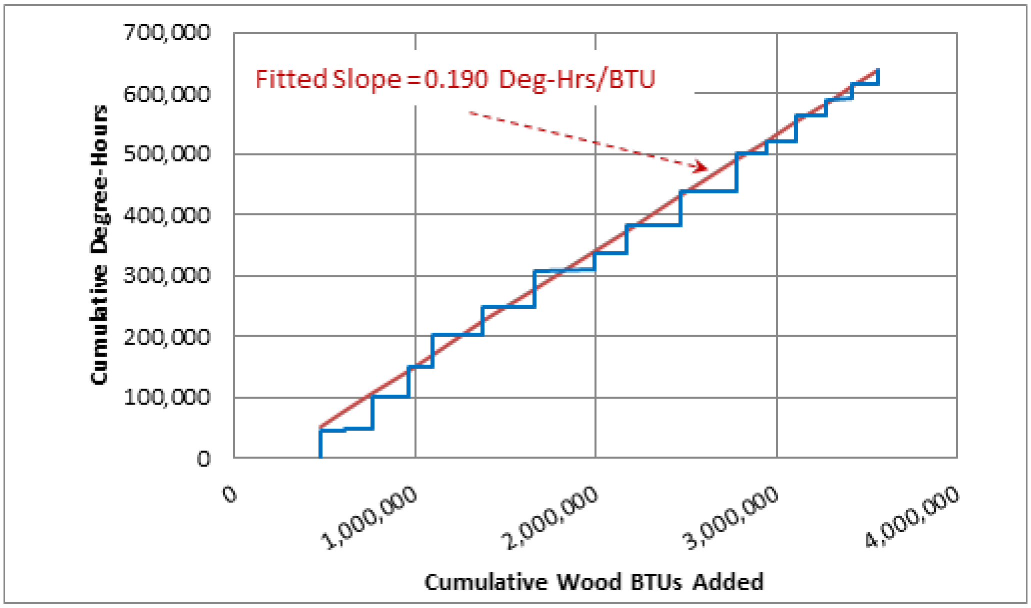


Table 5.6-4 lists the resulting fitted temperature slopes developed for each of the 16 Mixed and Primary wood device households with valid data. As shown in the highlighted column, the fitted slope (representing the relationship between measured flue temperature and fuel energy) differed across the devices by roughly an order of magnitude due to the aforementioned factors. Also listed for each household are the specific wood devices and sensor locations where the thermocouples were mounted on each device.

(As noted below Table 5.6-4, separate fitted slopes were developed for two distinct portions of sampling in household W-01, that corresponded to validated sampling periods before and after the thermocouple fell off the wood stove and was re-attached in a slightly different location.)

Using the individually fitted relationships for the wood-burning devices in each of these households developed based on that initial portion of the instrumentation period where wood loadings were measured (1-2 weeks), wood BTU usage estimates could be reasonably predicted based solely on the thermocouple-based flue temperature measurements over the entire (6-10 week) sampling period for each household.

As discussed later under "Quality Assurance and Data Validation," installation/removal diaries, homeowner observations and temperature traces over the entire sampling period for each wood device were carefully examined to ensure validity of the thermocouple data.

Table 5.6-4
Fitted Temperature/Fuel Energy Slopes for Sampled Wood Devices

Res. ID	Heated Area (ft^2)	Device No.	Wood Device	Temp. Slope (°F-hrs/BTU)	Temperature Sensor Location
M-02	2900	1	Wood Stove	0.190	Back of single wall stove pipe
M-03	2500	1	Wood Stove	0.078	Uninsulated flue pipe
M-04	1770	1	Wood Stove	0.072	Under the door
M-05	1900	1	Fireplace	0.142	Left firewall
		2	Wood Stove	0.175	Not recorded
M-06	3000	1	Wood Stove	0.046	Under the door area
M-08	1760	1	Wood Stove	0.120	Below door area
M-09	2600	1	Wood Stove	0.200	On side of firebox under heat shield
W-01	1250	1	Wood Stove	0.039, 0.043[a]	Uninsulated stove pipe
W-03	2488	1	OWB	0.031	Firebox door edge
W-04	2100	1	Wood Stove	0.046	Uninsulated exhaust stove pipe
W-05	5000	1	OWB (multi-fuel)	0.027	Exhaust flue
W-06	915	1	Wood Stove	0.042	On side of firebox under heat shield
W-07	4580	1	OWB	0.013	Fan motor
W-08	1400	1	Wood Stove	0.125	Side of stove
W-09	884	1	Wood Stove	0.130	Back of stove pipe
W-10	575	1	Wood Stove	0.115	Uninsulated stove pipe

[a] Two separate fitted slopes were developed for this wood stove because the thermocouple fell off during the instrumentation period and as re-attached at a slightly different location for the remainder of the sampling.

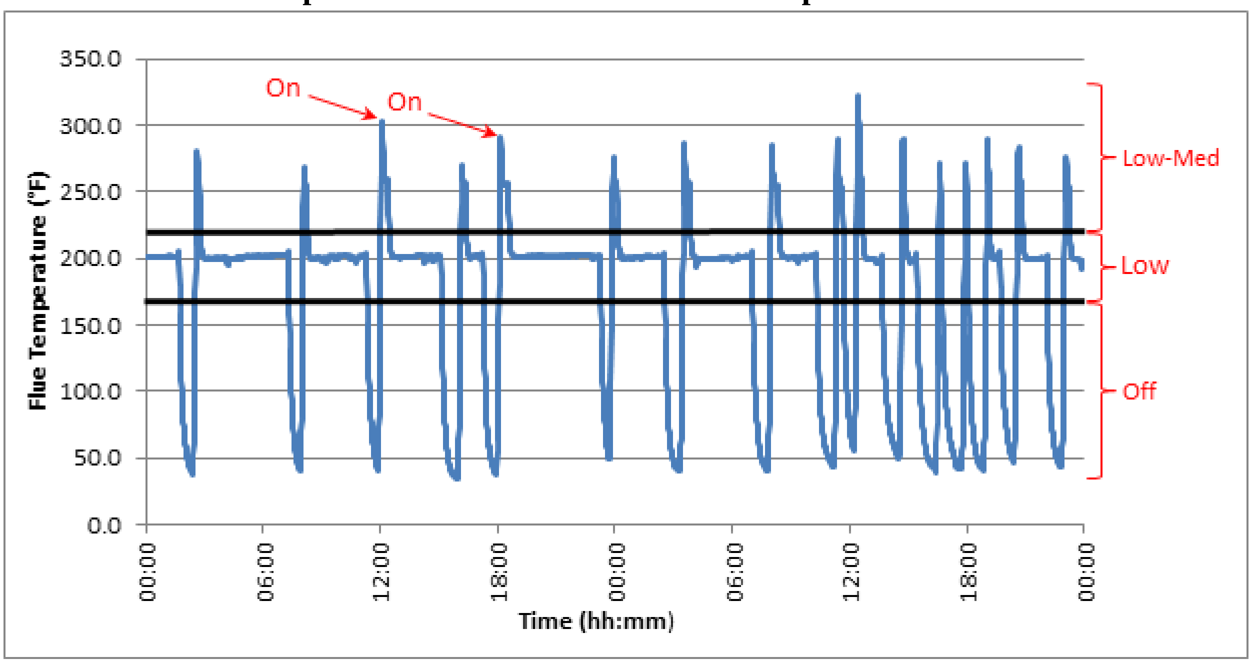
<u>Direct Vent Fuel Oil</u> - Direct Vent fuel oil combustion technology is used for both central home heating and room space heating. Both the large and small units use three or four fuel flow rates which are staged in response to ambient temperature and thermostat setting. This variable fuel flow precludes the use of the simple hourly fraction-on data loggers used with traditional constant-flow on/off centralized oil boilers. Instead, data loggers set to record flue temperatures at one minute intervals were used. At the same time, fuel oil usage was recorded in a diary or log book, providing a cross check of final fuel oil usage estimates.

The control operation and the flue temperature recording position varied between households. The flue temperature patterns similarly varied. Some common patterns, however, emerged. The most common pattern involved a sudden rise from ambient to an elevated level, which would be held from one to several minutes, followed by a reduction to a lower level which could be maintained from a few minutes to an hour or more, followed by a drop back to the initial ambient level. The length of the "hold" period was related to the outdoor ambient temperature, with lower temperatures resulting in longer run times.

Trial and error assignments of fuel usage rates to the different intervals were used to calculate total fuel usage during a period when the total amount of fuel used was known (from the diary logs). In general, the best agreement between recorded and estimated fuel usage was found when the second to lowest fuel usage rate was assigned to the initial startup period, followed by the lowest fuel usage rate for the extended stabilized period.

Figure 5.6-12 presents a representative example of measured flue temperatures from a direct vent heater (in household O-06) that clarifies this approach. Note the flue temperature in this example returns to just below 50°F when the device is off. When the heater starts, the flue temperature rises above 250°F, and holds from one to several minutes. In Figure 5.6-12, these events are marked with red arrows at times around 12:00 and 18:00 on the first day. The temperature then drops to about 200°F and holds from several minutes to several hours. It then shuts off and the temperature returns to below 50°F. The thick horizontal lines demonstrate "cut points" of 170°F and 220°F that were used to identify the fuel flow modes for this specific direct vent heater, a Monitor 2400.

Figure 5.6-12
Sample Direct Vent Oil Heater Fuel Temperature Trace



The Monitor 2400 has the following four fuel rates[7]:

1. High - 0.319 gal/hour;
2. High-Medium - 0.240 gal/hour;

[7] Fuel rate data for each direct vent heater in the sample were looked up from published specifications based on the specific heater models identified in each household and recorded by CCHRC.

3. Low-Medium - 0.180 gal/hour; and
4. Low - 0.120 gal/hour.

Discussions with CCHRC confirmed these direct vent heater generally operate (under thermostatic control) at their lower fuel rates because they are often used as individual room heaters and are quite efficient. Thus as shown at the right of Figure 5.6-12, temperatures above the 220°F cutpoint established for this specific heater were assumed to reflect operation of the device at its Low-Medium setting. Flue temperatures between 170°F and 220°F were assumed to reflect operation at the Low setting. And temperatures below 170°F were assumed to reflect periods where the thermostatically controlled heater was shut off. For each region, fuel rates were translated into device energy use (in BTUs). Direct vent heaters generally operate on Fuel Oil #1 (125,000 BTU/gal).

The first day of operation in the example corresponds to a day with a low outdoor ambient temperature that results in a high demand and nearly continuous furnace operation. The second day demonstrates the reduced demand on warmer days, with furnace operation in the day time hours cycling on for a short time and then remaining off for longer periods. This pattern of increasing furnace cycling frequency with higher ambient temperatures was typical.

Two higher capacity direct vent oil units and two supplemental direct vent room heating units were included in the study sample.

Quality Assurance and Data Validation

A number of problems were encountered in analyzing and processing the raw data from the instrumentation study. The raw data from CCHRC were provided in individual spreadsheets for each household. In addition to the raw measurements, each household spreadsheet included detailed descriptions of the heating devices and locations within each house, the heated building space, wood/oil usage diaries/logs and most importantly, installer/remover or homeowner observations regarding any operational issues noted during the sampling (e.g., a thermocouple stopped working or fell off). All results were carefully reviewed for completeness and reasonableness in assessing whether all or a portion of the data measured in each sampled household were deemed valid.

The temperature measurement sensors presented the greatest difficulty. The thermocouples were intended to be mounted in contact with the flue surface. It was sometimes noted that the thermocouples detached from the surface, and the recorded results reflected the significant drop in temperatures recorded at those times. In other cases it appeared as if the thermocouple electrical connection to the data logger was intermittent or failed, as reflected by large negative readings (-328°F was typical). The results, therefore, were carefully reviewed to remove these data from the final results. It was also important that the temperature recorded during the calibration period when the fuel was being weighed be consistent with the temperatures recorded before and after this period. Three wood burning homes were removed from the sample because flue temperature recording problems invalidated the results.

The base time unit of all resulting data streams was adjusted to one hour intervals. The standard centralized oil-based loggers began with a one hour time base. The wood burning flue temperature loggers recorded data every five minutes. The direct vent temperature loggers recorded data every minute. In all cases, calculated BTUs for each device were tabulated on an hourly basis (i.e., five-minute and one-minute flue temperature-based BTUs were summed over each hour). Device and ambient temperatures reported for the hour were averaged.

Results from homes with more than one heating source were aligned to start and end at the same time. For example, the data logger used to measure fuel oil usage might have been activated three hours before the logger used to monitor wood stove flue temperature was installed and operating. In this instance, the oil data for those initial three hours were discarded. In other cases, at the end of a sampling period a logger might have been removed and allowed to continue running for several hours. If one logger failed during the trial, the results from loggers for any other heating devices in the household were also discarded to ensure the remaining sample was not biased in accounting for interactions/usage patterns between the two heating sources.

Table 5.6-5 summarizes the household-by-household data validation results from the original 30 household sample. Four of the 30 households (shaded rows in Table 5.6-5) had instrumentation failure or other issues. All the data from these households (M-01, M-07, M-10 and W-02) were invalidated and discarded from further analysis. As summarized in Table 5.6-5, data for portions of the instrumentation duration in some households that were suspect were also discarded. In general, the homes with oil heating ran much more consistently, with no corrections or deletions required for any sampling period. As noted earlier, the wood heating homes required more effort to validate and assemble consistent data sets. All told, roughly 85% of the originally measured data were validated/corrected and utilized as the basis for the Fairbanks home heating energy model.

Separate spreadsheets containing data for each household as received from CCHRC were combined into a single database during the data validation and quality-assurance processing. The final validated database consisted of time-aligned records of hourly energy usage and outdoor ambient temperature by residence.

Each hourly record in the final database contained the household ID, heated space, ambient temperature and the measured/calculated energy use (in BTUs) for each of five device types found in the sample:

1. Woodstoves/Inserts (WS);
2. Fireplaces (FP);
3. Outdoor Wood Boilers (OWB);
4. Central Oil Boilers/Furnaces (COil); and
5. Direct Vent Oil Heaters (DV).

The final database contained over 25,200 valid hourly energy use records. This represented an average sampling duration of 970 hours or 40 days per household for the 26 valid households.

Table 5.6-5 **Home Heating Instrumentation Data Validation Summary**	
Res. ID	Data Validation Results by Household
O-01	This is a 2,448 ft^2 home with central oil heating. The monitor was installed on 12/15/10 and removed 1/26/11. A total of 1,011 hours or 42 days of data were collected from this residence.
O-02	This is a 1,500 ft^2 home with central oil heating. The monitor was installed on 12/23/10 and removed on 2/16/11. A total of 1316 hours or 54 days of data were collected from this residence.
O-03	This is a 3,000 ft^2 home with central oil heating. The monitor was installed on 12/16/10 and removed on 1/27/11. A total of 1,015 hours or 42 days of data were collected from this residence.
O-04	This is a 2,912 ft^2 home with central oil heating. The monitor was installed on 12/16/10 and removed on 1/27/11. A total of 1,014 hours or 42 days of data were collected from this residence.
O-05	This is a 1,400 ft^2 home heated with a main direct vent (DV) oil furnace (40,000 BTU/hr) and a smaller DV bedroom unit (20,000 BTU/hr). The monitors were installed on 12/16/10 and removed on 1/27/11. A total of 1,007 hours or 42 days of data were collected from this residence.
O-06	This is a 1,200 ft^2 home heated with a single DV oil furnace. The monitor was installed on 12/16/10 and removed on 1/27/11. A total of 994 hours or 41 days of data were collected from this residence.
O-07	This is a 1,200 ft^2 home with central oil heating. The monitor was installed on 12/21/10 and removed on 2/04/11. A total of 1085 hours or 45 days of data were collected from this residence.
O-08	This is a 2,200 ft^2 home with central oil heating. The monitor was installed on 12/17/10 and removed on 2/04/11. A total of hours 1,255 or 52 days of data were collected from this residence.
O-09	This is a 2,100 ft^2 home with central oil heating. The monitor was installed on 12/23/10 and removed on 2/02/11. A total of 993 hours or 41 days of data were collected from this residence.
O-10	This is a 2,200 ft^2 home with central oil heating. The monitor was installed on 12/22/10 and removed on 2/09/11. A total of 1,152 hours or 48 days of data were collected from this residence.
M-01	This 2464 ft^2 home is heated by a wood stove and a central oil fired boiler. The results from the home were discarded when it was determined that logging of wood added was performed while there was a poor thermocouple connection, invalidating the temperature vs. BTU calibration.
M-02	This 2900 ft^2 home is heated by a wood stove and a central oil boiler. Recordings were made from 12/14/2010 through 1/27/2011. The wood stove was not used from 12/28/2010 through 1/21/2011. The temperatures recorded after 1/21 were inconsistent with the earlier recordings, and were thus discarded. The oil usage logger performed well through the entire period, but results after 12/28 were discarded to maintain a representative sample for a home with two heat sources. The final data set for both appliances was from 12/14/10 through 12/28/2011, a total of 337 hours or 14 days.
M-03	This 2500 ft^2 is heated by a wood stove and a central-oil fired boiler. Valid recordings were made from 12/15/2010 through 1/18/11 and from 2/3/11 through 2/4/11. The occupants were on vacation in late January so the period was removed from the data set to maintain a representative sample for a home with two heat sources. The final data set included 835 hours or 34 days of valid results.
M-04	This is a 1770 ft^2 residence with a wood stove and oil fired boiler with holding tank. Valid recordings were made from 12/22/10 through 2/4/11, a total of 45 days or 1,080 hours. An interesting inverse relationship between ambient temperature and wood usage was observed during the test period. Wood usage dropped off when the ambient temperature was above 0°F.
M-05	This is a 1900 ft^2 residence with a central oil fired boiler supplemented with heat from a fireplace and a wood stove. About 22% of the total BTU energy observed in the home was produced by the wood appliances. Data was collected from 12/21/10 through 02/15/11, a total of 55 days or 1,320 hours. The inverse wood fuel usage with ambient temperature seen with M-04 continued with this household.
M-06	Residence M-06 also uses an oil fired central boiler with holding tank and a wood stove. The 2700 ft^2 home includes an additional 300 ft^2 allowance for a basement that is generally maintained about 50°F. Data was collected here from 12/21/10 through 2/03/11, a total of 45 days or 1,080 hours.

Table 5.6-5
Home Heating Instrumentation Data Validation Summary

Res. ID	Data Validation Results by Household
M-07	Residence M-07 used an oil fired central boiler as its primary heating source, with a wood stove as a secondary source. The data logger used to monitor oil usage was not initialized during installation. No data was recorded during the study. Multiple problems were noted with the thermocouple used to monitor the wood stove. This residence was not used in analysis. It is a 1400 ft^2 residence. Monitors were installed on 12/23/10 and removed 02/03/11. No usable data was collected.
M-08	Residence M-08 uses an oil fired central boiler as its primary heating appliance (91%) and a secondary wood stove (9%). Wood usage was sporadic. The home has an area of 1,760 ft^2. The monitors were installed on 12/20/10 and removed on 02/04/11. A total of 43 days, or 1,035 hours of data were collected.
M-09	This residence used an oil-fired central boiler as its primary heating appliance (79%) and a wood stove for the remainder. Wood usage was not particularly related to outdoor ambient temperature. The home has an area of 2600 ft^2. The monitors were installed on 12/16/10 and removed 1/28/11. A total of 1033 hours, or 43 days, of data were collected.
M-10	This residence used an oil-fired central boiler and two wood stoves. Thermocouple problems with the wood stoves made the data from this home unusable. It is a 3,000 ft^2 home. Approximately 1,000 ft^2 was shut off during day time hours. The monitors were installed on 12/17/10 and removed 02/03/11. No usable data was collected from this home.
W-01	This residence is primarily heated with a wood stove (83%), with central oil heating as a secondary source (17%). The home has 1,300 ft^2 of area, with a 50 ft^2 unheated artic entry, leaving 1,250 ft^2. The data collection monitors were installed on 12/24/10 and removed 2/9/11. The wood stove thermocouple fell off on 12/26/11 and was restored on 1/3/11. Both the wood and oil data collected in this period was removed from the data. A net total of 946 hours or 39 days of valid data were collected and used in the analysis.
W-02	This residence has a wood stove and direct vent oil heater. The thermocouple on the DV oil heater fell off after installation. A total of 120 gallons of fuel oil were reported as used, but could not be allocated. The wood data collected during the same time period was, therefore, invalidated. The home has 980 ft^2 of heated area. The monitors were installed on 12/17/10 and removed 2/24/11. No data from this home was used in the final analysis.
W-03	This is a 2,488 ft^2 home. Primary heating is from an Outdoor Wood Boiler (OWB). Oil is used to ignite the OWB. A thermocouple monitor was installed on the firebox door on 12/17/10. A separate monitor was installed on the oil burner on 12/28/10. Data collection ended on both systems on 1/31/11. Only results collected when both monitoring systems were functioning were used in the final analysis. A total of 815 hours of data, or 34 days, were collected.
W-04	This is a 2,100 ft^2 home that uses a central oil boiler and a wood stove. While initially classified as a primarily wood burning home, it was found that 72% of the heating energy during the sample period came from oil, with the remainder from wood. It was treated as a MIXED home in the analysis. Both the oil and wood sensors fell off during the data collection period. All data after the wood sensor came off on 12/31/10 was discarded. The sensors were installed on 12/15/10 and were removed on 2/9/11. Only 15 days of data were used in the final analysis.
W-05	This is a 5,000 ft^2 residence heated with an OWB and an indoor boiler. The OWB provided 96% of the total BTUs consumed during the sample period. The monitor equipment was installed on 12/16/10 and removed on 1/28/11. A total of 1260 hours or 53 days of data were collected.
W-06	This is a 916 ft^2 home heated primarily with a wood stove (99%) and a supplemental direct vent oil heater. The monitoring equipment was installed 12/16/10 and removed 1/28/11. An absence between 1/13/11 and 1/25/11 was noted when the data was examined. Wood usage stopped and oil heat was used to maintain the home during this period. The results for both oil usage and wood usage during the interval were removed from the final data. A total of 9041 hours or 31 days of data were retained.

Table 5.6-5 Home Heating Instrumentation Data Validation Summary	
Res. ID	Data Validation Results by Household
W-07	This is a 4,580 ft^2 home heated with an OWB and two indoor oil-fired boilers. Oil and Wood were nearly equal in the production of BTU's during the sampled period (50% each). The monitors were installed 12/26/10 and removed on 2/9/11. Valid data was retained for a total of 810 hours or 33 days.
W-08	This is a 1,400 ft^2 home using primarily a wood stove (67%) for heating, with a direct vent oil heater as a secondary source (33%). Sensors were installed 12/30/10 and removed 2/19/11. A total of 1022 hours or 43 days of data were collected from this home.
W-09	This is an approximately 884 ft^2 home. It is heated exclusively with a wood stove. The data logger was installed on 12/21/10 and removed on 2/1/11. A total of 1006 hours or 41 days of data were collected.
W-10	This is a 575 ft^2 residence heated with a wood stove and DV oil heater. A problem was found with the DV temperature sensor, but the oil usage log revealed only 10.5 gallons of fuel oil were consumed during the sampling period. This is equivalent to about 10% of the total BTUs produced by the wood consumed during the same period. The sensors were installed on 12/28/10 and removed on 2/16/11. A total of 31 days of data were used.

Summary of Validated Results

Table 5.6-6 displays the average daily energy consumption (in BTUs) by heating device type for each of the remaining homes with validated data during the sampling period. The valid households are sorted by sampling group (O-Oil Only, M-Mixed/Primary Oil, W-Mixed/Primary Wood). Cells with "n/a" under the daily energy use columns reflect devices that do not exist in that household (e.g., wood devices in the first three columns are not applicable for the group of Oil Only households). Total average daily energy (across all devices in each household are listed in bold. As shown in the "Total" column of Table 5.6-6, average household energy use ranges from 235,075 BTU/day (O-06) to 1,938,204 BTU/day (W-03), an eight-fold range, with a sample average of 839,622 BTU/day.

The rightmost two columns in Table 5.6-6 list the average wood energy percentage and daily energy use per unit area (BTU/Day per ft^2). As shown and discussed earlier, the sample of households exhibit varying amounts of wood vs. oil use for each of the wood and oil devices measured. (All heating devices in each household were instrumented. The selected sample included only those five device types listed earlier and displayed in the table.)

As summarized in a footnote, wood-burning energy use for household M-05 was assigned entirely to its fireplace, even though the home also had a wood stove (and a central oil boiler). Although energy use was measured separately for both the fireplace and the wood stove, it was all assigned to the fireplace. The reason for this adjustment is the belief that few homes have multiple wood-burning devices, based on repeated home heating surveys of several hundred residences each. Since this was the only household with a fireplace in the instrumented study sample, the adjustment provided a "cleaner" approach for development of the fireplace-specific components of the resulting energy model.

Table 5.6-6
Validated Home Heating Instrumentation Sample Summary

Res. ID	Heated Area (ft²)	Avg. Household Daily Energy Use by Device (BTU/day)						Wood Use Pct.	BTU/Day per ft²
		Woodstove	Fireplace	OWB	CentOil	DirectVent	**Total**		
O-01	2,448	n/a	n/a	n/a	792,168	n/a	**792,168**	0%	324
O-02	1,500	n/a	n/a	n/a	972,312	n/a	**972,312**	0%	648
O-03	2,775	n/a	n/a	n/a	1,086,937	n/a	**1,086,937**	0%	392
O-04	2,912	n/a	n/a	n/a	918,548	n/a	**918,548**	0%	315
O-05	1,400	n/a	n/a	n/a	n/a	374,537	**374,537**	0%	268
O-06	1,000	n/a	n/a	n/a	n/a	235,075	**235,075**	0%	235
O-07	1,200	n/a	n/a	n/a	654,180	n/a	**654,180**	0%	545
O-08	2,200	n/a	n/a	n/a	1,021,203	n/a	**1,021,203**	0%	464
O-09	2,100	n/a	n/a	n/a	950,833	n/a	**950,833**	0%	453
O-10	2,200	n/a	n/a	n/a	454,368	n/a	**454,368**	0%	207
M-02	2,900	265,559	n/a	n/a	720,968	n/a	**986,528**	27%	340
M-03	2,500	249,740	n/a	n/a	830,137	n/a	**1,079,876**	23%	432
M-04	1,770	205,229	n/a	n/a	394,971	n/a	**600,200**	34%	339
M-05	1,900	See Note a	295,208[a]	n/a	973,542	n/a	**1,268,751**	23%	668
M-06	3,000	449,953	n/a	n/a	773,096	n/a	**1,223,049**	37%	408
M-08	1,760	73,282	n/a	n/a	744,147	n/a	**817,429**	9%	464
M-09	2,600	164,336	n/a	n/a	583,305	n/a	**747,640**	22%	288
W-01	1,250	903,366	n/a	n/a	174,558	n/a	**1,077,924**	84%	862
W-03	2,488	n/a	n/a	1,820,881	117,323	n/a	**1,938,204**	94%	779
W-04	2,100	395,049	n/a	n/a	978,646	n/a	**1,373,696**	29%	654
W-05	5,000	1,172,540	n/a	n/a	41,932	n/a	**1,214,472**	97%	243
W-06	915	284,096	n/a	n/a	n/a	n/a	**284,096**	100%	310
W-07	4,580	n/a	n/a	459,869	427,135	n/a	**887,004**	52%	194
W-08	1,400	201,224	n/a	n/a	n/a	94,377	**295,601**	68%	211
W-09	884	278,445	n/a	n/a	n/a	n/a	**278,445**	100%	315
W-10	575	297,106	n/a	n/a	n/a	n/a	**297,106**	100%	517
Averages	**2,129**	**379,994**	**295,208**	**1,140,375**	**680,515**	**234,663**	**839,622**	**35%**	**418**
Pct. of Energy Use		**23%**	**1%**	**10%**	**62%**	**3%**	**100%**	-	-

n/a = Not applicable.
[a] Energy use for both wood devices (fireplace and woodstove) were combined to better represent fireplace as secondary device.

In assessing this "all-as-fireplace" adjustment of wood energy use in household M-05, diurnal patterns of wood use in both devices was examined and within this household, found to be generally similar. Both wood devices were used on most days and typically fueled in the early morning and evening hours. By assigning all of the wood energy to the fireplace, this household was recast in a manner that matched the overwhelming majority of homes where fireplaces are used as a secondary heating source.

Daily energy use by device averaged across the household sample is shown in the "Sample Averages" row at the bottom of Table 5.6-6. These are averages over only those households with the given device (e.g., the OWB average is based on OWB household averages for W-03 and W-07).

The bottom row of Table 5.6-6 shows energy use percentage splits by device and is based on averages across all households, irrespective of whether they have each device. As shown, oil vs. wood energy use was split at 65% oil (62% CentOil + 3% DV) and 35% wood (10% stoves, 1% fireplaces, 24% OWBs). This is generally consistent with the oil/wood splits seen in local home heating surveys, but not identical since these instrumented households were a targeted, not random sample.

Comparison of Measured Energy Use to Independent Source

Although the instrumented households represented a stratified (oil/mixed/wood), targeted sample, the tabulated results were compared to an independent estimate of wintertime residential space heating energy use in Fairbanks. In a November 2013 report[8] prepared for the Interior Gas Utility (IGU), Northern Economics assembled results from local residential survey data and found average annual household space heating in Fairbanks to be 154 mmBTU/year. (In the report, it is shown on a natural gas energy basis of 151 Mcf[9], with gas energy content of 1.023 mmBTU/Mcf.)

To account for the strong seasonal variation in energy use and enable a direct comparison to the instrumented data collected between December 2010 and February 2011, a monthly space heating demand profile published in a June 2013 natural gas engineering study[10] by Northern Economics was used to allocate the annual usage from the IGU-sponsored survey to a daily average over a December-February period. From Figure 5 of that study, 43.7% of annual space heating demand occurs during those three winter months (Dec-Feb). An independent estimate of daily average energy use during this period was then calculated as:

$$154 \text{ mmBTU/year} \times 43.7\% \div 90 \text{ days/year} = 0.750 \text{ mmBTU per average Dec-Feb day.}$$

When accounting for the fact that Dec 2010-Feb 2011 period was cooler than the long-term average for the same three months as measured at Fairbanks International Airport (-10°F vs. -4°F long-term), the 840,000 BTU/day sample average from Table 5.6-6 compares reasonably well to the independent estimate of about 750,000 BTU/day. So though a targeted sample, the instrumented database appears to reasonably approximate average Fairbanks household space heating energy use during winter.

[8] Northern Economics, "Natural Gas in the Fairbanks North Star Borough: Results from a Residential Household Survey, prepared for the Interior Gas Utility, November 2013.
[9] Mcf = Thousand cubic feet.
[10] L. Cuyno and P. Burden, Estimated Natural Gas Demand for NS LNG Project memorandum, June 21, 2013.

HOME-HEATING ENERGY MODEL

After the data were validated and assembled into a unified database of hourly energy use by household and device, a least-squares regression analysis was performed to develop a predictive model of household space heating energy use, calibrated to Fairbanks practices and wintertime ambient conditions.

Several different forms of regression models and independent variables were evaluated. This evaluation included the following elements:

1. Assessment of the data to examine patterns/dependencies in home heating energy use;
2. Identification of terms or variables with statistically-significant explanatory power; and
3. Examination of equations/model forms that could be readily applied in conjunction with other data in an episodic emissions inventory workflow.

Patterns Revealed from Instrumented Sampling

In support of the first element, a series of scatter plots of the validated data were prepared and examined to evaluate temporal energy usage patterns and both external (ambient) and internal (device usage practices in multi-device households) factors. Figure 5.6-13 through Figure 5.6-15 present time series plots of hourly space heating energy use by household for Oil Only, Mixed (Oil & Wood) and Primary Wood households, respectively. In each plot, hourly energy use for each household is plotted using distinct symbols/colors on the left axis. Ambient temperatures recorded for each hour are plotted in blue against the right axis. (The right axis is appropriately scaled to locate the ambient temperature series at the upper portion of the panel so it can be more clearly compared to the energy use data located largely toward the bottom.)

In Figure 5.6-13, ambient temperatures are shown to hover near the -20°F range at the start of the instrumentation period (mid-December) before rapidly warming to over +40°F in early January. Temperatures then head back near -20°F (and drop as low as -40°F) by mid-January, then rise to around +10°F at the end of the month before dropping toward -20°F again at the end of the instrumentation period in mid-February. Not surprisingly, plots for each Oil household's energy use tend to track variations in ambient temperature, but in the opposite direction.

Some other interesting patterns can also be seen. Comparing household sizes (shown earlier in Table 5.6-6) there is loose correlation between heated area and average energy use (R^2=0.41), although some homes exhibit disproportionally higher or lower energy use than reflected by their size (e.g. O-02 is higher, O-10 is lower). These size vs. energy use variations are also likely due to differences in construction/insulation and thermostat settings between households. As shown in Figure 5.6-4, the oil households exhibit differences in the magnitude of temporal variations over their sampling periods and generally show high degrees of scatter when plotted on an hourly basis, with one exception. Household O-06 (plotted with tan markers) is a small home (1,000 ft^2) heated entirely with a single direct vent heater. Based on its thermostat settings and heat output of the unit, the heater often operates at a steady rate of about 15,000 BTU/hour (which shows up as a horizontal line near the bottom of the plot). (The other

Figure 5.6-13
Hourly Instrumented Energy Usage (BTU/hour), Oil Only Households

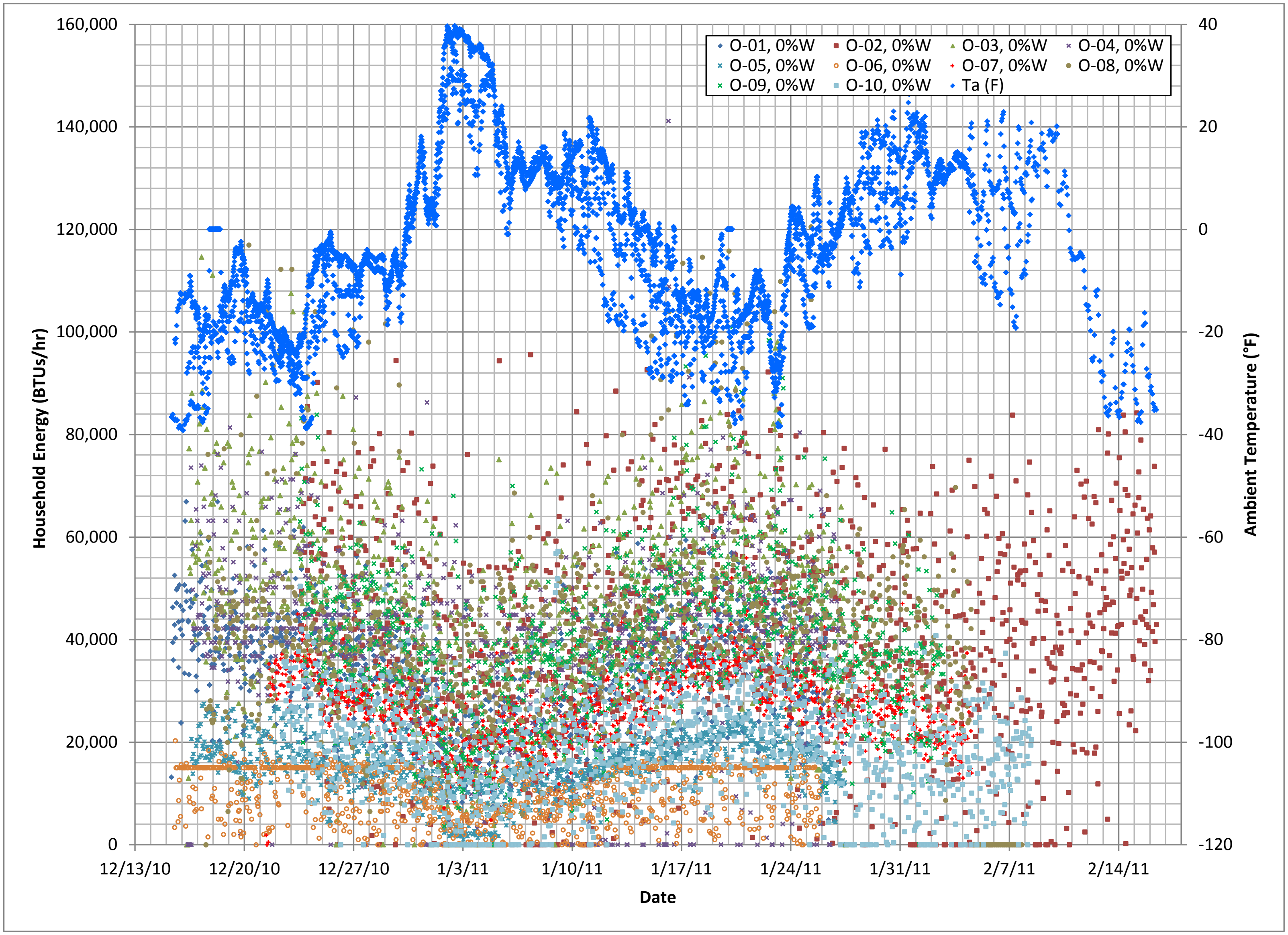


Figure 5.6-14
Hourly Instrumented Energy Usage (BTU/hour), Primary Wood Households

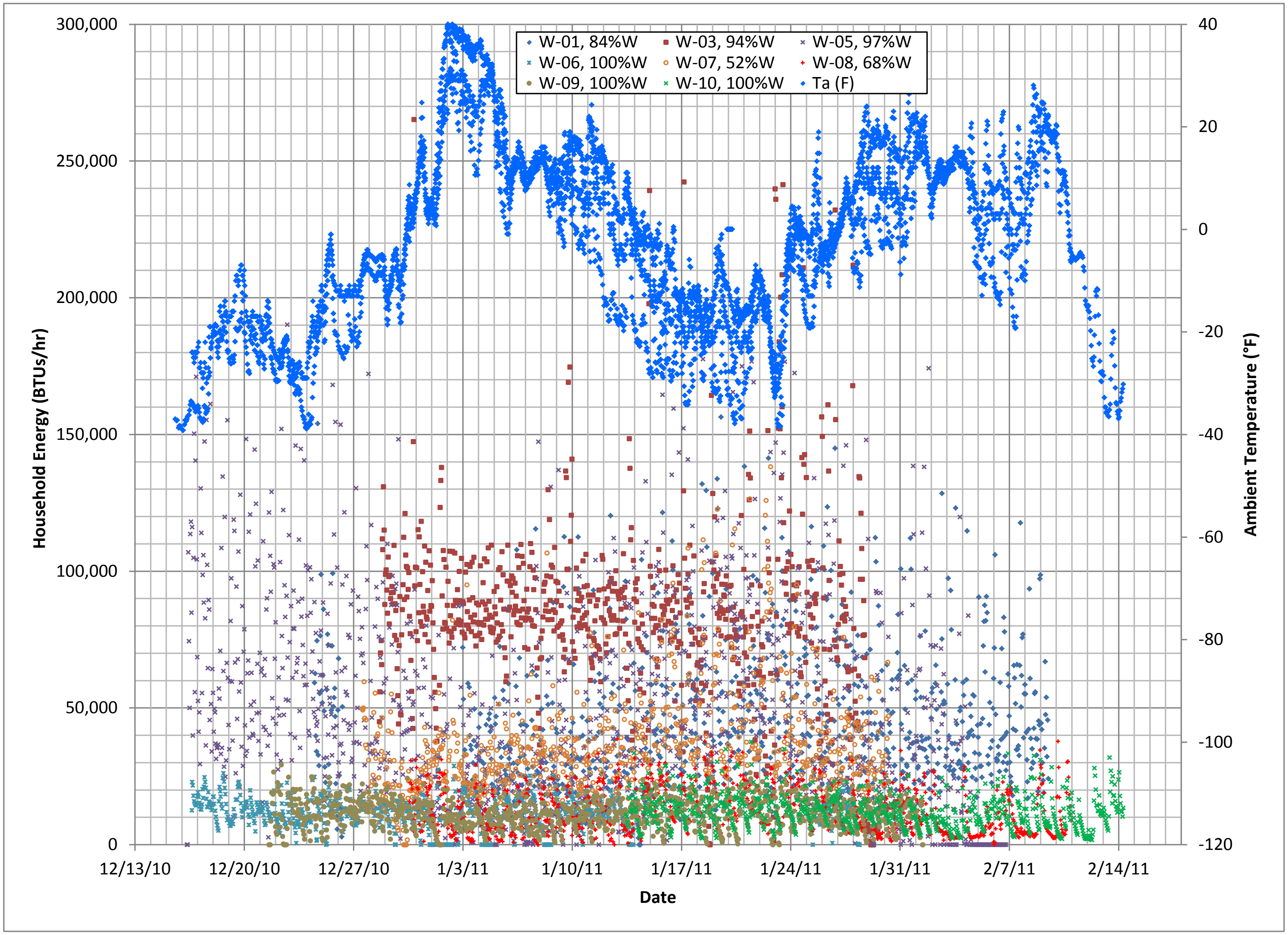
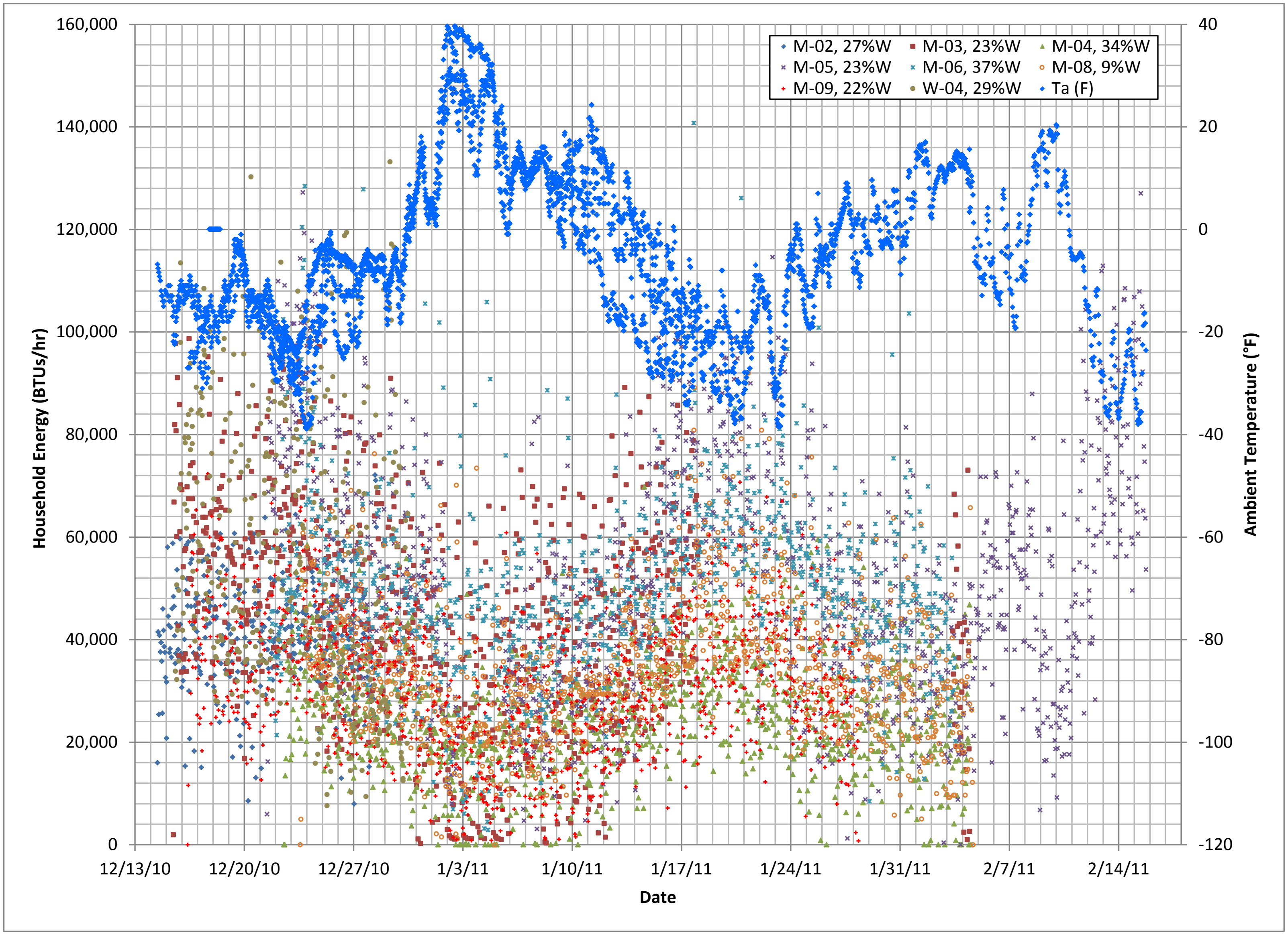


Figure 5.6-15
Hourly Instrumented Energy Usage (BTU/hour), Mixed Households



direct vent oil home, O-05, has two direct vent units which operated together are less steady in their output.)

Despite the high degree of visible scatter for the Oil households shown in Figure 5.6-13, temporal variation or scatter in hourly energy use was much higher in the Primary Wood households. As shown in Figure 5.6-14 (note the larger scale for energy use on the left axis), there tends to be much more scatter in hourly energy use, both within and across households that primarily burn wood. And at least on an hourly basis, energy use in Primary Wood households (R^2=0.05) is less correlated with ambient temperature than in Oil Only (R^2=0.19) homes. This lower correlation (on an hourly basis) is likely due to the fact that wood devices are not thermostatically controlled like oil devices. In addition the Primary Wood group includes some households using oil as a secondary heating source, which affects total household energy use and hourly patterns.

Figure 5.6-15, the final plot in this series, shows hourly energy use for the Mixed households (those primarily heated using oil with wood as a secondary heating source). As shown earlier in Table 5.6-4, Wood household W-04 exhibited only 29% wood use, even though it was pre-screened as a primary wood home. Thus, it was plotted with the Mixed households group in Figure 5.6-15.

Comparing Figure 5.6-15 (Mixed) to Figure 5.6-13 (Oil), the variation in energy use with ambient temperature appears more pronounced for Mixed households than Oil homes. A likely explanation for this is that in Mixed households, wood is used as supplemental or secondary heat, with oil providing a “base load” of heat energy. Given the relative heating efficiency of wood devices (40%-70%) compared to oil devices (over 80%), use of wood devices with lower efficiency, especially on colder days would result in more household energy use on those days compared to a case when the home is entirely oil-heated.

Since a portion of the scatter in this set of plots results from variation in hourly use, a second set of daily energy use plots were also developed and examined. Figure 5.6-16 shows total daily household energy use for each home in the Mixed group. Solid lines (with different colors and markers are used to show total daily energy use for each household. Similar to the earlier plots, daily average ambient temperature is plotted in Figure 5.6-16 using blue “diamond” markers against the right axis.

Comparing daily energy use across the Mixed households, day-to-day variations in energy use for all homes tend to work in reverse to ambient temperature variations. Homes M-05, M-06, M-03 and W-04 tend to exhibit higher energy use than others in the group (although the valid sample duration for W-04 was shorter than the rest). These four homes tended to be larger in size (M-06, M-03), use lower efficiency wood devices (M-05 used fireplace) or use a higher wood-based heating fraction (M-06=37%) than the rest of the group.

To better understand the interactions in energy use for these multi-device households, Figure 5.6-17 presents daily energy use by device (oil, wood and total) for a selected set of Mixed households, M-04 and M-06, to illustrate two common patterns exhibited in multi-device homes even though their wood heating fractions are similar (~35%). For each household, total energy is

Figure 5.6-16
Daily Instrumented Energy Usage (BTU/day), Mixed Households

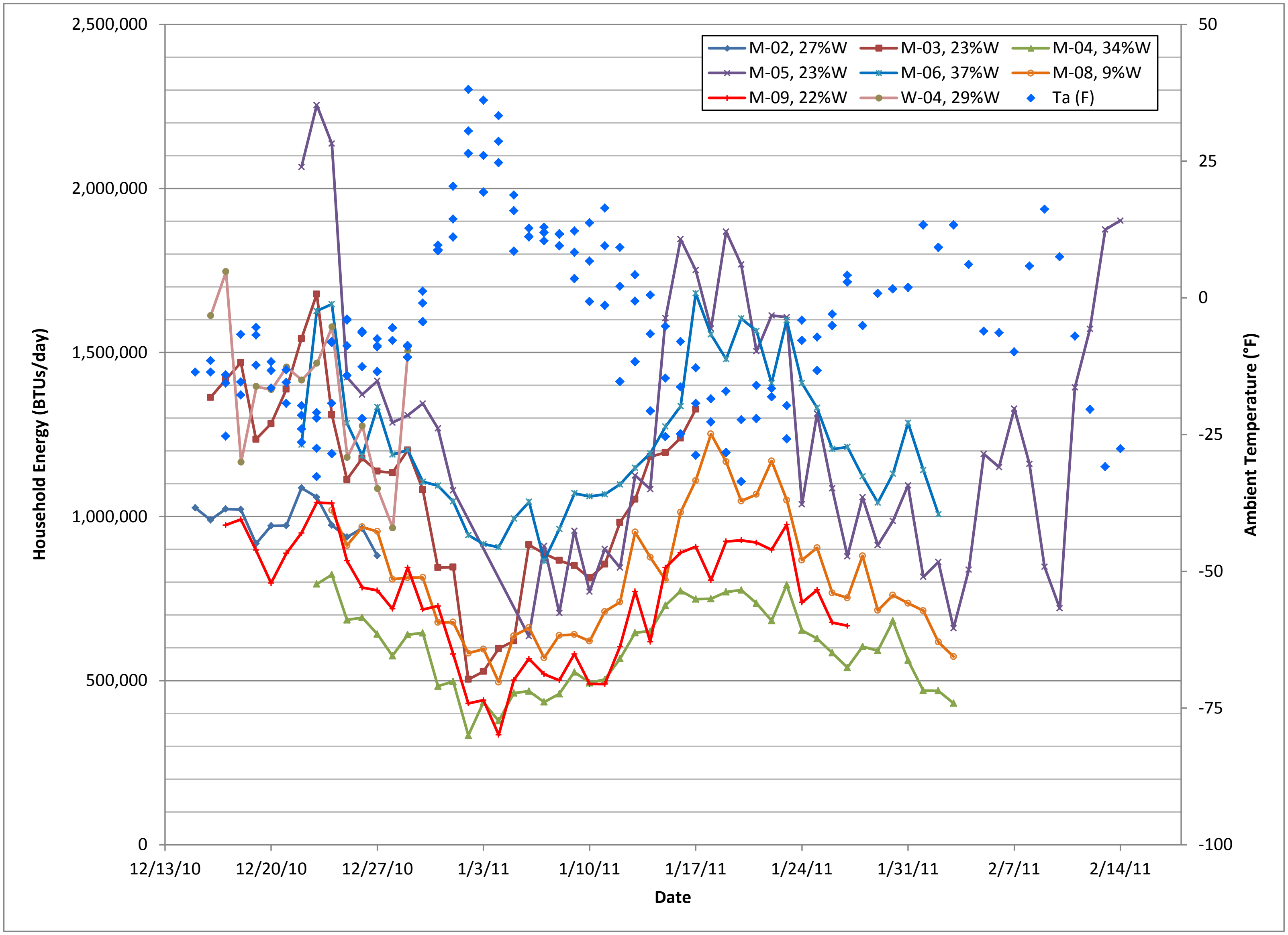
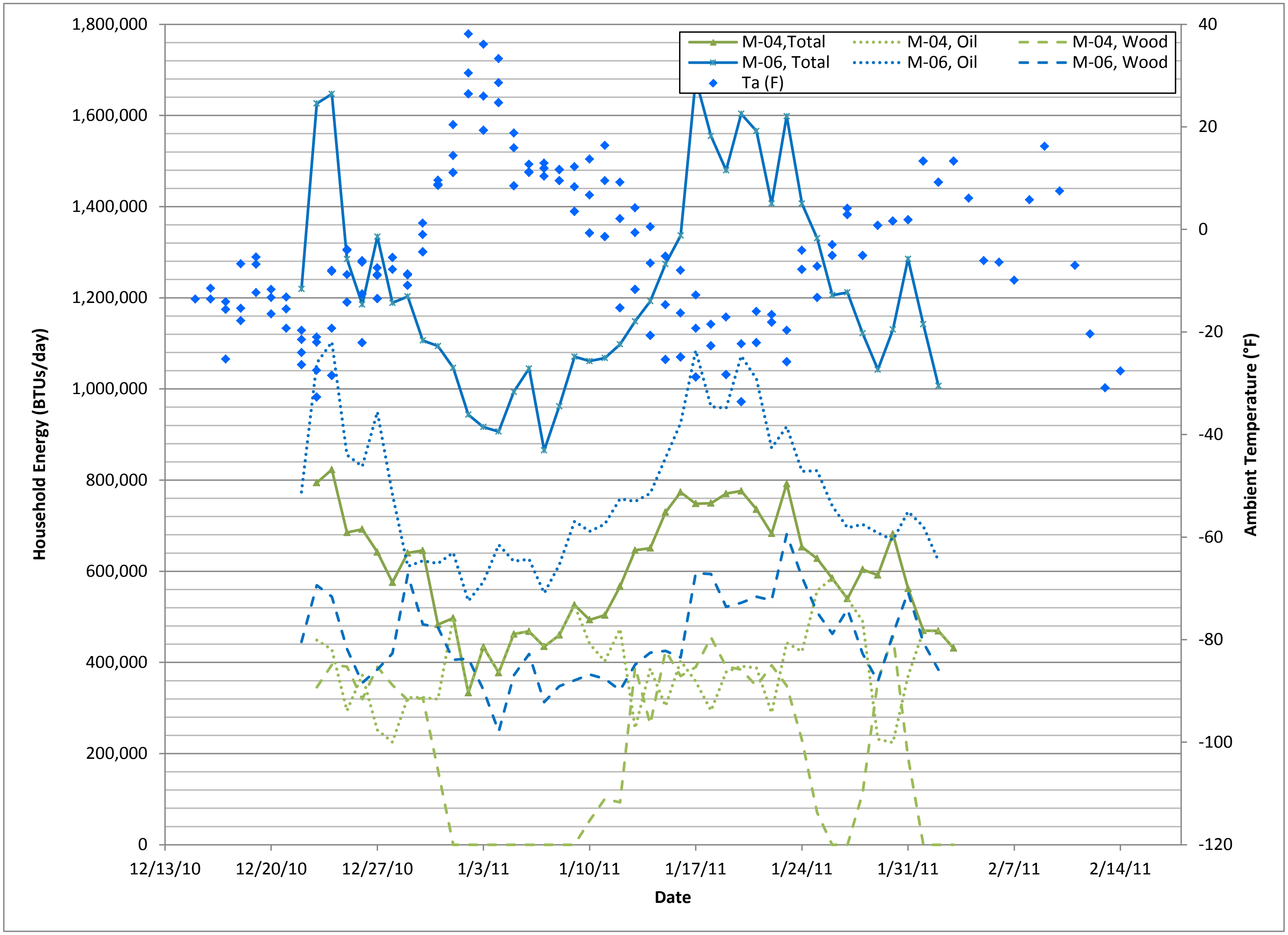


Figure 5.6-17
Daily Instrumented Energy Usage (BTU/day) by Fuel Type, Mixed Households M-04 and M-06



plotted using a solid line and marker points; oil and wood energy are plotted using dashed and dotted lines, respectively. (Again, daily ambient temperature is also plotted against the right axis).

Shown in green lines in Figure 5.6-17, daily energy use in household M-04 exhibits a typical pattern, especially in smaller or more efficient/insulated homes. On colder days, both oil and wood are used (e.g. during the first week of sampling, from 12/22/10 through 12/30/12 and again from 1/10/11 and 1/24/11.) On warmer days (e.g. from 1/1/11 through 1/9/11 and again on 1/26/11) wood use actual dropped to zero and all heat was supplied by the oil device.

On the other hand, household M-06 displayed a different pattern in day-to-day interaction between oil and wood heating as shown in the three blue lines in Figure 5.6-17. Both devices were used to supply heat on every day of the sampling period, and with one exception around 12/29/10, the ratio in supplied heat between the oil and wood devices was fairly steady (roughly 2:1 oil-to-wood).

Identification and Selection of Explanatory Variables

Based on the review of space heating energy use patterns and examination of plotted results, several factors or variables were considered in building the regressions supporting the energy home heating model. These factors included:

- *Ambient Temperature* - Ambient temperature, as the primary measure of heat loss from the structure. An effort was made to determine if the energy use coefficient for temperature varied in different parts of the day, but there is insufficient data to make the determination.

- *Building Size* – Heated dwelling space was used as a marker of heat demand for each structure; the more heated area, the higher the heating demand.

- *Hour of Day* - Denoted by the beginning of the hour (the 00 hour is midnight-1 am). Dummy variables indicating the 24 individual hours of the day provide a diurnal profile of energy use (with other factors held constant) that reflects a combination of human behavior, particularly the times of day when the dwelling is occupied, and environmental contributions, such as the influence of daylight and dark on heat loss from the structure.

- *Device(s) Used* – The mix of devices used in each household was also considered. Examination of the patterns of variance in instrumented data suggested that both the type (in single-device homes) and the interaction (in multi-device homes) was a factor in explaining both total household energy use and diurnal usage patterns. Since wood devices are generally less efficient than oil devices, it is expected that all other factors being equal, homes primarily burning wood would exhibit higher energy use. In addition, the ability to thermostatically control the usage rate of oil-fired devices results in a different diurnal profile than for wood-burning devices, which are generally not thermostatically controlled (except hydronic heaters) and require manual fuel loading.

- *Day Type* - Weekday versus weekend days were distinguished, represented as a dummy variable for weekends, to capture overall differences in energy use that correspond different occupancy and behavioral patterns between weekdays and weekends. An effort was made to determine if weekend-related differences could be related to time of the day, but there was insufficient data to make the determination. Thus, the weekend factor represents the average amount by which energy use is different on a weekend day versus a day during the work week.

The analysis was guided by the statistical significance of the estimated terms (at 95 percent confidence), but it did not require statistical significance in all cases because of the relatively small sample size available for study, especially for fireplace and direct vent oil devices. Terms have been retained where they appeared to be both important to capture and plausible, even if the desired level of statistical significance was not universally reached.

Inventory-Driven Regression Models – Given the review of the energy use patterns and selection of a set of factors believed to account for observed variations in the measured data, a series of multivariate regression models were considered and tested. In addition to statistical significance, a key element that guided the selection of appropriate model forms/equations was the applicability of the model for use in representing residential energy use (and device specific emissions) to support wintertime episodic modeling of space heating emissions in the SIP inventories. After trying a number of different models/forms, the final Fairbanks residential space heating energy use model consisted of two separate, but serially-applied regression models that are listed below:

1. Daily Model – a single model predicting daily household space heating energy use (in BTUs) as a function of the average mix of the device usage in the home and its heated area; and

2. Hourly Device Models – a suite of device-specific models predicting diurnal usage patterns and unique responses of each device to daily ambient temperature variations and day of week effects.

Daily Model – The Daily model was a least-squares regression fitted model predicting daily household space heating energy as a function of heated living area and the fraction of each heating device type for each of the five device types represented in the instrumented sample:

1. Wood Stove (WS);
2. Fireplace (FP);
3. Outdoor Wood Boiler (OWB);
4. Central Oil (CO); and
5. Direct Vent Oil (DV).

These five device types account for over 95% of wintertime residential space heating energy use according to multiple residential home heating surveys performed in Fairbanks.

For each sampled day the total BTUs for each device type within a household were summed to find the total BTUs. The fraction of the total for each heating device type was then calculated by dividing the BTUs for the type by the total household BTUs for that day. A conventional multiple factor linear regression was performed on the resulting dataset. A total of 1,018 heating days were included in the regression.

The Daily model accounts for energy use effects of the size of the home and the relative efficiency of the different heating devices used within the home and their interactions on a given day. The Daily model predicts household energy per day (BTUs/day) using the following multivariate equation:

$$\boldsymbol{HH\ DayBTU = C_0 + C_1A + C_2\%WS + C_3\%FP + C_4\%OWB + C_5\%CO + C_6\%DV} \quad \textbf{(1)}$$

Where:

HH DayBTU = predicted daily household space heating energy use (BTU/day);
A = heated dwelling area (ft^2);
%WS = percentage of average winter household energy use by wood stoves;
%FP = percentage of average winter household energy use by fireplaces (no inserts);
%OWB = percentage of average winter household energy use by outdoor wood boilers;
%CO = percentage of average winter household energy use by central oil devices;
%DV = percentage of average winter household energy use by direct vent heaters; and
C_0 - C_6 = least squares-fitted coefficients (C_0 is the intercept).

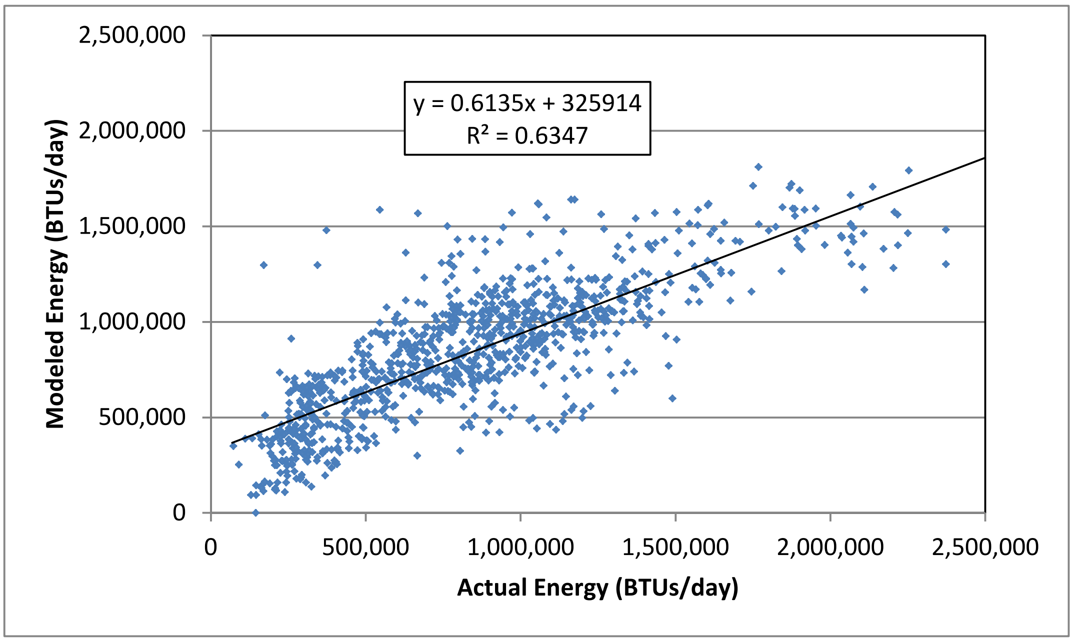
As discussed later in the "Emission Calculation Details" section of this appendix, heated dwelling area and fractions of device energy use over an entire winter season are elements that can be obtained from sources such as FNSB Assessor parcel database (building size) and home heating survey results (energy use splits over an entire winter season). Thus for use in subsequent inventory calculations, these are known independent variables. Table 5.6-7 lists the resulting least squares-fitted coefficients used for the Daily model.

Table 5.6-7
Daily Model (Device Distribution and Area Model) Coefficients

Coefficient - Term	Value
C_0 - Intercept	-392560
C_1 – Heated Area	133.07
C_2 - % Wood Stove	799199
C_3 - % Fireplace	2462593
C_4 - % Outdoor Wood Boiler	1576799
C_5 - % Central Oil	987823
C_6 - % Direct Vent Oil	504552

Figure 5.6-18 presents a scatter plot of predicted daily household energy using the Daily regression model against actual measurements from the instrumented study database. Predicted estimates were generated by inputting the size and average device energy use splits of each household in the study. The plotted trend line and its equation box show that total daily BTUs in each household (predicted as a function of its size and device mix) are fairly well correlated with measured values (R^2=0.63), although the positive intercept for the trend line and the slope below unity indicate a bias toward over-prediction at the low end of measured daily energy and under-prediction at the high end. Given that ambient temperature dependence has yet to be factored in, this Daily model performs reasonably.

Figure 5.6-18
Modeled vs. Actual Household Energy by Day - Total Daily BTUs



To see how well the Daily model represents day-to-day energy use for each specific heating device, a set of similar scatter plot comparisons were developed showing predicted vs. measured energy use for each device in the household.

In Figure 5.6-19, predicted daily energy use from household wood stove use is also reasonably well correlated with measurements (R^2=0.66). Since the predictions here are being driven by the average energy split for wood stoves across all sampling days (for households equipped with wood stoves, the Daily model generally performed well in representing day-to-day and household-to-household wood stove energy use.

Figure 5.6-20 presents predicted vs. measured household energy use for fireplaces. As it shows, predicted energy use for fireplaces is not as well correlated as for wood stoves and tends to over-represent measured values. These relatively poor predictions are largely due to the fact

Figure 5.6-19
Modeled vs. Actual Household Energy by Day - Daily Wood Stove BTUs

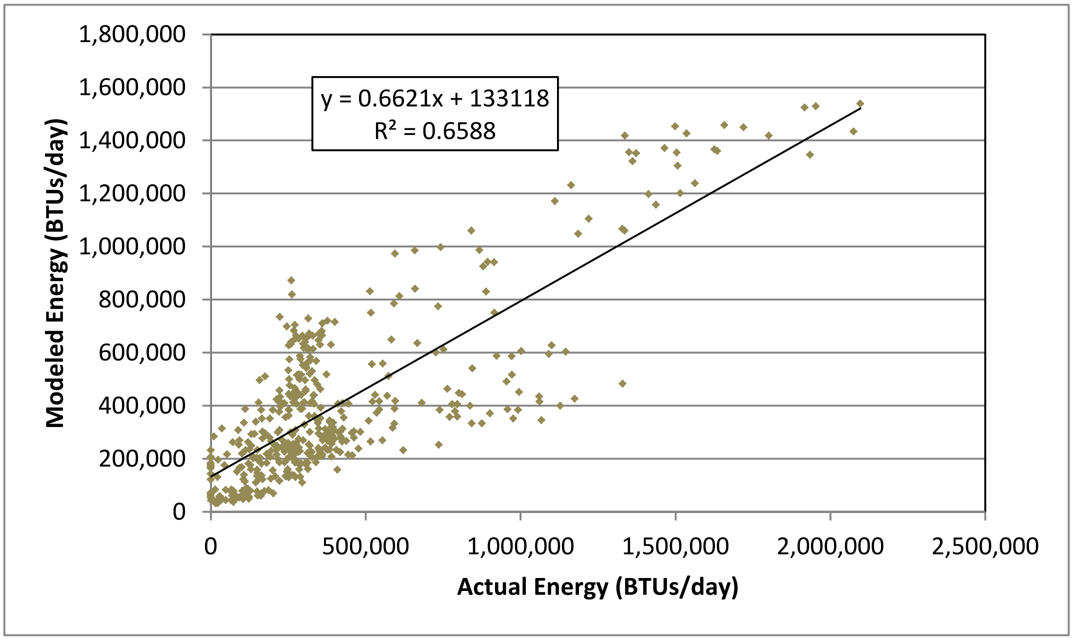
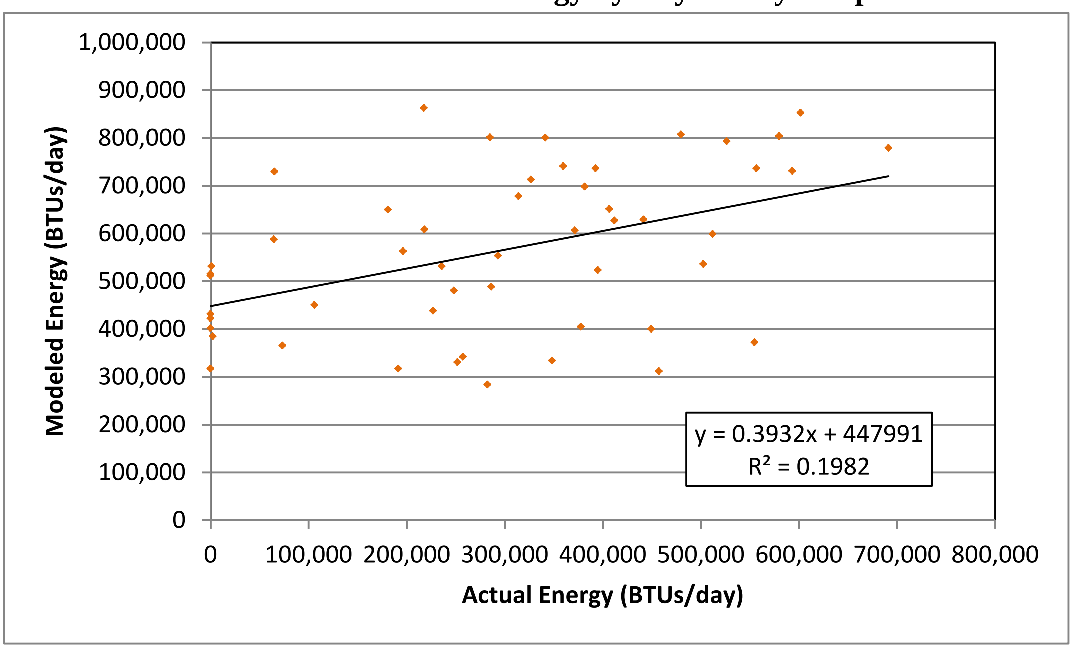


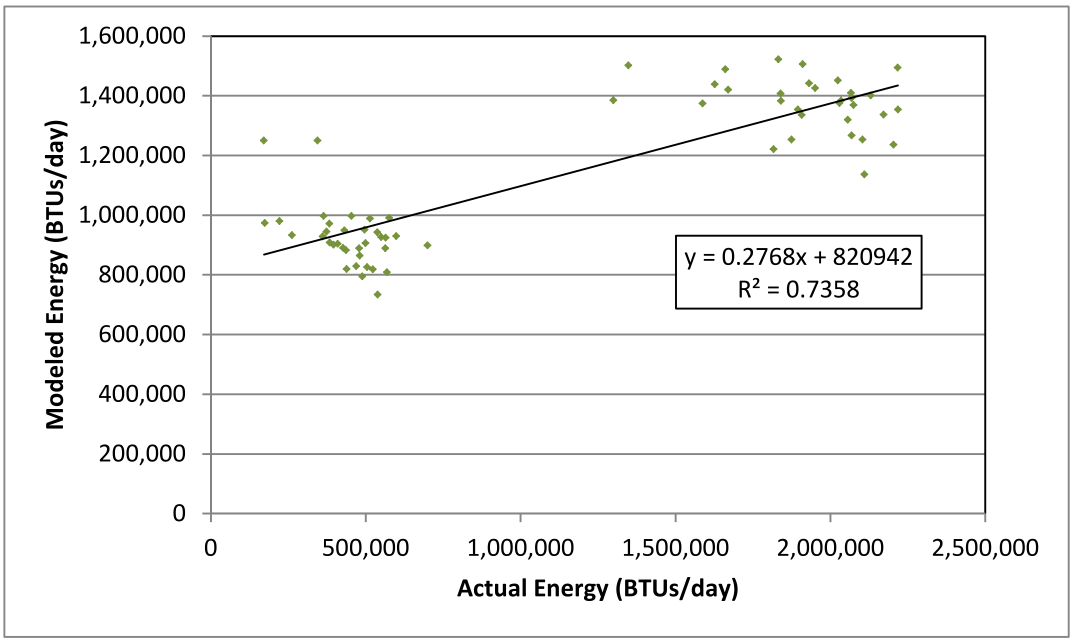
Figure 5.6-20
Modeled vs. Actual Household Energy by Day - Daily Fireplace BTUs



that the instrumented study sample consisted of only a single household that used a fireplace and it was used intermittently as a secondary heating source. Evidence of this can be seen in Figure 5.6-20; there are several data points on the y-axis, meaning the model is predicting some fireplace energy use (based on average splits) on given days when the fireplace was not operated. The regression model would certainly benefit from additional sampling of fireplaces.

Predicted vs. measured daily household energy use for outdoor wood boilers (OWBs) is presented in Figure 5.6-21. Although it shows predicted results are better correlated with actual measurements (R^2=0.74), its two "clusters" of data represent the only two households with OWBs in the study sample. And the usage patterns exhibited by these two OWBs appear to span a wide range of actual practice. In the first OWB household (W-03), the OWB supplied 94% of the household heat energy over its measurement period, while in the second (W-07) there was a more even balance between OWB and central oil heating (52% vs. 48%).

Figure 5.6-21
Modeled vs. Actual Household Energy by Day - Daily Outdoor Wood Boiler BTUs



As shown in the preceding three plots, it is mildly problematic to accurately predict daily energy use for wood-burning devices on an individual device and household basis, because of their somewhat intermittent use. In contrast, predicted oil device household energy use better matched measured values.

Figure 5.6-22 and Figure 5.6-23 show predicted vs. measured household energy use for central oil devices and direct vent heaters, respectively. Predicted estimates for both oil device type are very well correlated with daily measurements ($R^2 \geq 0.8$), partially reflecting the fact that oil devices generally provide "base load" heat from day to day.

Figure 5.6-22
Modeled vs. Actual Household Energy by Day - Daily Central Oil Device BTUs

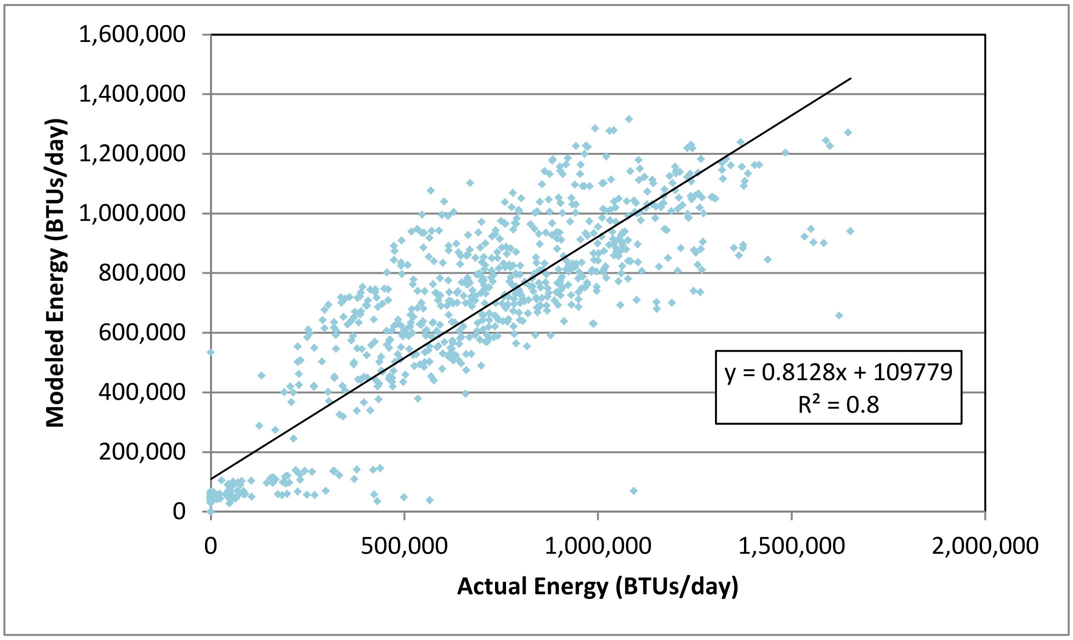
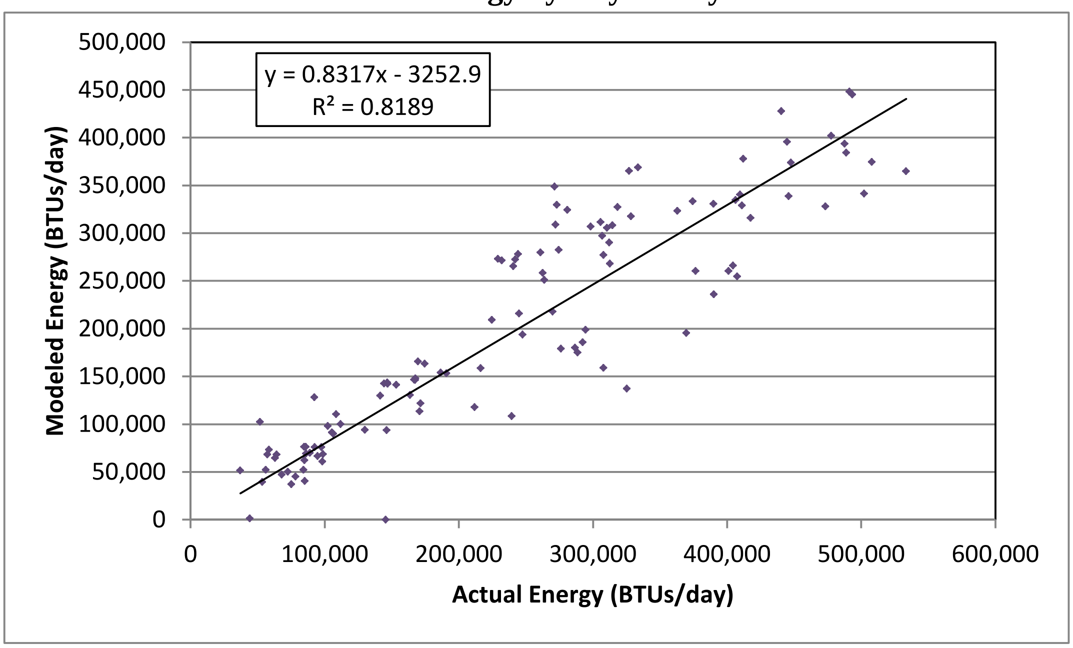


Figure 5.6-23
Modeled vs. Actual Household Energy by Day - Daily Direct Vent Heater BTUs



Hourly Model – The second and final component of the complete home heating energy model consisted of the development of a separate set least-squares regression models of hourly energy use (one for each device type) that incorporated ambient temperature, weekday/weekend and diurnal variation influences unique to each device.

Since most wood-burning devices are not thermostatically controlled and require "manual" loading of fuel, their diurnal (and weekday/weekend) energy use patterns would be dictated by someone being home (and loading wood into the firebox). Depending on the size and burn duration range of each type of wood device, one might expect a different set of statistically fitted diurnal and weekday/weekend profiles than for oil devices.

Ambient temperature, an obvious explanatory variable for residential space heating energy use was incorporated into the Hourly model. (Incorporation of ambient temperature dependence was tested in both the Daily and Hourly models. It was determined that by incorporating it into the Hourly model rather than Daily model, device-specific responses to variations in ambient temperature could be better modeled.)

Thus, the set of Hourly models (one for each device type) was developed using the following equation form:

$$\boldsymbol{HH\ HrBTU_i = C_0 + C_{1,i} + C_2T + C_3DayType} \quad \textbf{(2)}$$

Where:

HH HrBTU_i = predicted hourly household space heating energy use (BTU/hr) in hour *i* (ranging from 0 to 23);
T = daily ambient temperature (in °F);
DayType = a dummy variable for weekday (value 0) and weekend (value 1) days and
$C_0 - C_3$ = least squares-fitted coefficients (C_0 is the intercept).

Daily, rather than hourly ambient temperature was found to produce marginally better fitted results for the set of Hourly regression models. This was attributed to the high degree of overall variance in the hourly measurement data (especially at the individual device level) and the fact that wood device are generally not thermostatically controlled and depending on the device and its settings, have a wide range in burn duration (over 12 hours for some devices) for a single fuel load. This diminishes correlation with hourly temperatures. Therefore, the set of Hourly models were fitted using daily ambient temperatures (i.e. averaged over 24 hours) developed from the hourly ambient temperature data.

Table 5.6-8 lists the set of Hourly model coefficients for each of the five heating devices determined using least-squares fitted regressions. The "intercept" coefficients (C_0) for each device reflect a baseline, or average hourly energy use for that device. The series of 24 C_1 coefficients (hourly index from 0 to 23) reflect fitted hour-specific adjustments to the baseline (C_0) level unique to each device type. In the fitted regression, the baseline was assigned to Hour 0 (midnight to 1 AM). This is why the C_1 value shown for Hour 0 in Table 5.6-8 is zero.

Table 5.6-8 Hourly Model (Temperature, Day, Diurnal Variation Model) Coefficients						
Coefficient	Hour Index	Coefficient Values by Device				
		Woodstove	Fireplace	OWB	CentOil	DVOil
C_0 – Hourly, base	n/a	14952	11085	49737	29322	6047
C_1 - Hourly	0	0	0	0	0	0
	1	130	-1425	-1388	547	79
	2	-606	-2559	-1893	1108	130
	3	-2111	-3779	-1299	2050	89
	4	-3205	-4731	-2308	3351	421
	5	-4699	-4183	-3496	3849	-44
	6	-3477	-4026	-4218	5173	-95
	7	-1527	-3447	-4510	6640	-548
	8	-869	-1650	-2484	5774	-494
	9	1359	-1013	-1247	4562	-431
	10	1855	-1135	-257	4069	-157
	11	2702	-1383	-292	2979	-165
	12	1836	70	218	3001	185
	13	593	2822	1869	1774	-245
	14	1156	3418	-1223	2311	-21
	15	1531	2359	-2377	1762	-214
	16	2617	116	-5490	2411	-339
	17	1964	498	-6101	1719	-546
	18	3940	619	-7770	1328	-1676
	19	3561	-262	-8067	81	-1668
	20	5282	-19	-7050	359	-596
	21	3117	284	-5169	-1507	-1165
	22	571	1370	-3537	-817	-628
	23	1056	947	-1756	-457	-242
C_2 - Ambient Temp.	n/a	-263	-244	-175	-434	-170
C_3 - DayType	n/a	406	-655	-3548	-82	79

n/a – Not applicable

At the bottom of Table 5.6-8, the C_2 and C_3 coefficients are shown for each device reflecting daily ambient temperature and weekday/weekend differences, neither of which is modeled as varying by hour, but rather as an offset term that is constant over the day. As expected, the ambient temperature coefficients (C_2) are all negative, reflecting increasing energy use with decreasing outdoor temperature. The ambient temperature coefficient for Central Oil is the largest (negative) value compared to those for the other devices. This makes sense since central oil devices are the predominant source of "base level" or entire heating in a large majority of the instrumented sample (as well as Fairbanks residences in general) and thus reflect the greatest response to ambient temperature.

Finally, the DayType (C_3) coefficients in the bottom row of Table 5.6-8 reflect a mixture of positive and negative values across the range of instrumented devices. Since the DayType dummy variable is 0 for weekdays and 1 for weekends, a positive value indicates greater predicted energy use for that device on weekend days relative to weekdays. The two oil devices show a weaker variation between weekend and weekday energy use than the wood devices, likely due to the fact that the oil devices are thermostatically controlled.

Combined Application of Fitted Regression Models - The final step in the development of the home heating energy model consisted of serially combining the two models into a "composite" model as follows.

First, the Daily model is applied to generate estimates of daily household energy use by device as a function of dwelling size and the device use fractions in a household (or group of households as described later in the "Emission Calculation Details" section of the appendix. Next, the Hourly model is applied (with separate sets of coefficients for each applicable device) to estimate hourly energy use by device, factoring in ambient temperature, day of week and diurnal usage pattern effects.

In order to properly impose the variations addressed by the Hourly model, a reference temperature and a reference day type must be assumed to allow normalization of the second model results when combined with the Daily model predictions. The overall average temperature during the instrumented study sampling period was chosen as the reference temperature (-3.5°F), while weekdays were chosen as the reference day type.

Once daily energy use estimates have been generated using the Daily model and daily estimates are divided by 24 to represent an average hourly value, the Hourly model is then applied twice (for each device type), first using the selected input ambient temperature and day type and next with the reference ambient temperature (-3.5°F) and reference day type (weekday). Ratios of actual day to reference day energy use for each device in each hour are then calculated for each set of Hourly model estimates.

Finally, the results from the Daily and Hourly model regressions are combined by summing the product of the Daily model energy for each type, the Daily model device fraction for each type, and the ratio of the Hourly model energy for each type at the desired conditions and the Hourly model energy for each type at the reference conditions as shown in the following equation:

$$\boldsymbol{HH\ BTU_{d,i} = {}^{DayBTU_d}/_{24} \times {}^{HrBTU\ Actual_{d,i}}/_{HrBTU\ Ref_{d,i}}} \qquad \textbf{(3)}$$

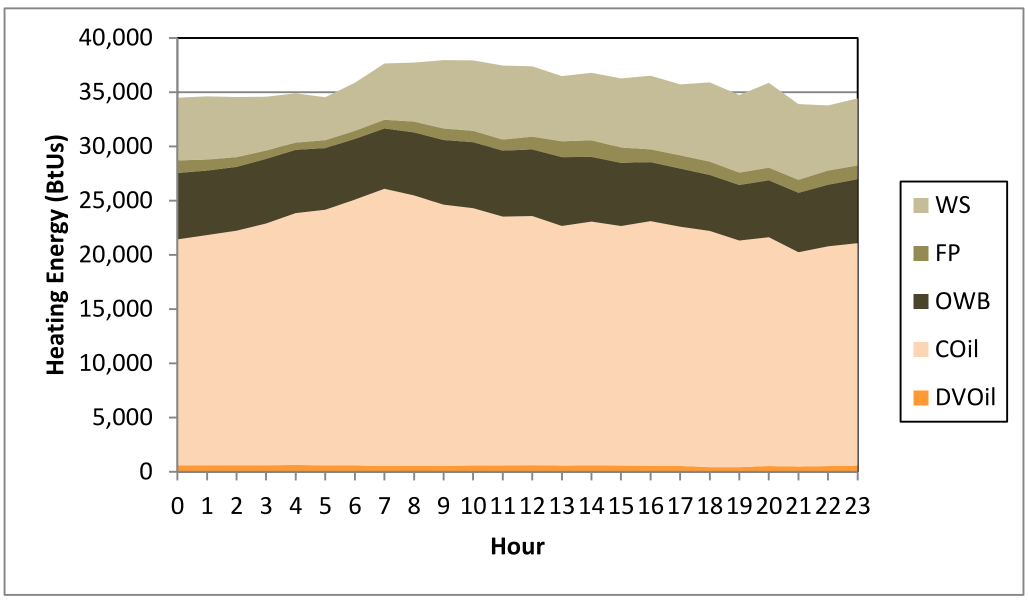
Where:

HHV = higher heating value (BTU/lb) which includes latent heat of vaporization;
LHV = lower heating value (BTU/lb) which excludes latent heat of vaporization;
HHV_{dry} = laboratory-measured energy content or bone dry HHV (BTU/lb);
MC_{wb} = wood moisture content (%, wet basis); and
1050 = a constant that represents the latent heat of vaporization (at 25°C).

Figure 5.6-24 through Figure 5.6-27 present estimates of hourly energy by device and hour for several sets of example conditions to illustrate how the combined space heating energy model responds to each of its input variables. In each figure, predicted household hourly energy use (in BTUs) is plotted by hour of the day (0 represents midnight to 1 AM) for each device type in a hypothetical household.

First, Figure 5.6-24 shows a case that represents a typical mix of household device usage splits identified in local home heating surveys, reflecting primary oil use and secondary wood use. It assumes a daily average ambient temperature of 0°F.

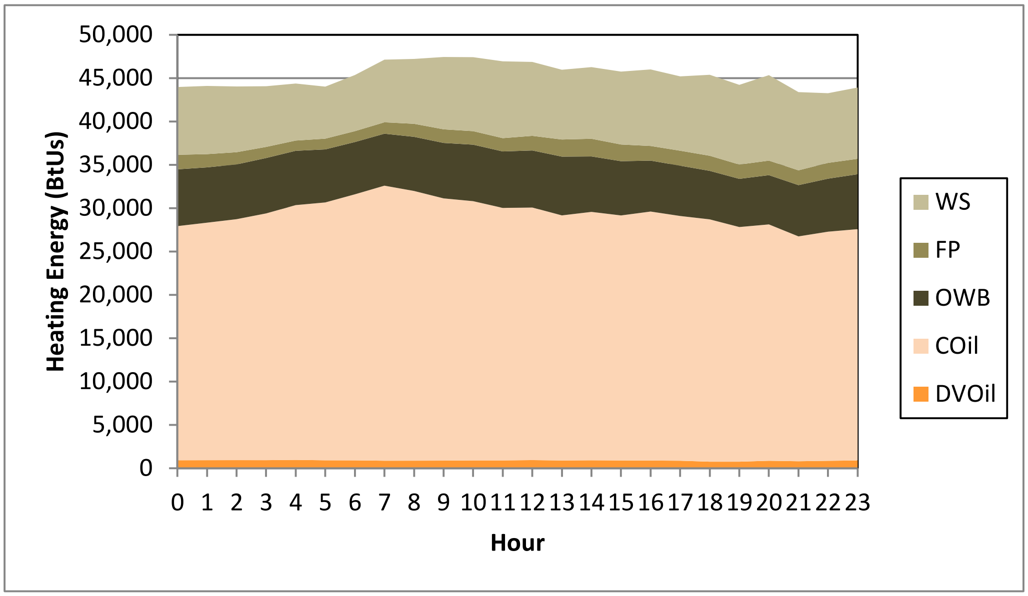
Figure 5.6-24
Combined Model Energy Use Case:
Dwelling Size = 2,129 ft^2, Temp = 0°F, Day Type = WD,
WS=22%, FP=1%, OWB=10%, CentOil=64%, DVOil=3%



(Although a single home is not likely to employ all five of these devices, the energy model was designed for use in space heating inventory calculations which as explained later in the "Emission Calculation Details" section of the appendix, is applied for large groups of

households. The energy model can also look at more simplistic one- and two-device per home scenarios, but it was designed for the broader inventory use explained above.)
Figure 5.6-25 shows predicted household energy use for the same device mix as in Figure 5.6-24, but at a colder -20°F daily ambient temperature. Expectedly, predicted energy use is over 20% higher (note the difference in vertical axis scales between the two figures).

Figure 5.6-25
Combined Model Energy Use Case:
Dwelling Size = 2,129 ft^2, Temp = -20°F, Day Type = WD,
WS=22%, FP=1%, OWB=10%, CentOil=64%, DVOil=3%



Next, Figure 5.6-26 illustrates a case representing a household primarily heated by wood, again at -20°F. In this example, wood burning devices collectively comprise 70% of the average winter season household energy use with oil used for the remaining 30%. Compared to Figure 5.6-25, this shows higher overall energy use (due to the relative inefficiency of wood devices compared to oil) and a different diurnal pattern.

Finally, Figure 5.6-27 shows the typical "primary oil" device mix case from Figure 5.6-25, but for a smaller dwelling size (1,500 vs. 2,129 ft^2). Comparing its results to those in Figure 5.6-25, a reduction in overall energy use of about 10% is predicted for the smaller home.

Thus, this series of plots demonstrates how the space heating energy model works and responses reasonably to changes in its inputs.

Figure 5.6-26
Combined Model Energy Use Case:
Dwelling Size = 2,129 ft^2, Temp = -20°F, Day Type = WD,
WS=55%, FP=5%, OWB=10%, CentOil=28%, DVOil=2%

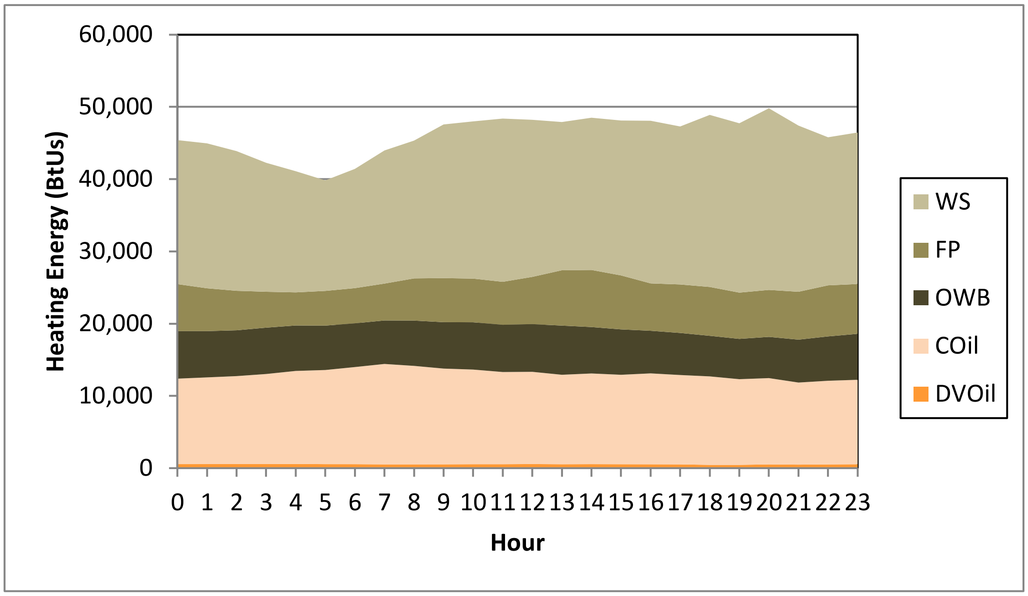
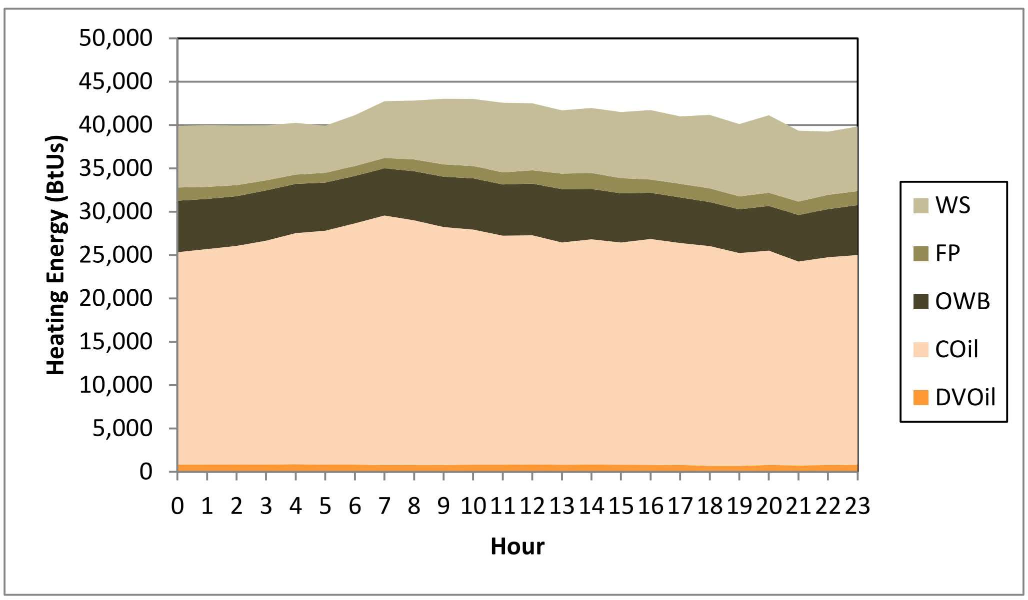


Figure 5.6-27
Combined Model Energy Use Case:
Dwelling Size 1,500 ft^2, Temp = -20°F, Day Type = WD,
WS=22%, FP=1%, OWB=10%, CentOil=64%, DVOil=3%



HOME HEATING – RESIDENTIAL SURVEYS

One of the key sources of data use to drive the residential heating energy model was information developed from a series of residential "Home Heating" (HH) telephone surveys regularly conducted by ADEC. These surveys have been conducted in 2006, 2007, 2010, 2011, 2012 and 2013 and have been used by ADEC and Borough to determine the mix of residential home heating devices and practices within the Fairbanks $PM_{2.5}$ Non-Attainment Area.

In addition to these broader HH surveys, the agencies also funded and coordinated two special surveys in 2013 specifically targeting wood-burning households, one in which more details were obtained on rated emission levels for certified devices, the other which further examined wood purchase and usage practices.

This section of the Emission Inventory Technical Appendix describes each of these two sets of survey instruments and summarizes the key data extracted from these surveys and processing performed for use in calculation space heating emissions within the SIP inventories.

HOME HEATING SURVEYS

Purpose – The primary purpose of these HH surveys was to collect up-to-date information on residential heating practices in Fairbanks during the winter season when extremely cold ambient temperatures cause a significant seasonal increase in fuel combustion for residential heating. Since the first surveys were conducted during the 2006 and 2007 winter seasons, ADEC has continued to fund similar annual surveys beginning again in early 2010. The rationale behind these continued surveys is to ascertain whether trends in the devices/fuels used to heat homes have changed over time. ADEC and the Borough also use the surveys to gauge public awareness about local air quality and control programs.

Basic Approach - The HH surveys were conducted by a specialized research survey firm, Hays Research Group (Hays), based in Alaska. Hays was directed to randomly sample residential households within the Fairbanks $PM_{2.5}$ non-attainment area, perform the telephone surveys and deliver the detailed, electronically recorded survey data results to ADEC. The telephone surveys were generally toward the end of each winter (e.g., the 2010 survey was conducted during February 2010) to get responses about heating patterns/practices while fresh in the minds of the respondents.

Targeted sample sizes for the first three HH surveys (2006, 2007 and 2010) were set at 300 households for each survey. For the 2011, 2012 and 2013 surveys, the targeted sample size was more than doubled, to 700 households. Within each survey, ZIP code-specific sampling targets were established based on household data from the 2010 U.S. Census and used to select stratified samples of residential households by ZIP code. (For the 2010 and earlier HH surveys, stratified ZIP code sampling was based on 2000 Census data, then later re-weighted to be consistent with the 2010 Census weightings. Composite metrics tabulated across ZIP codes from all surveys could then be compared in an unbiased manner.)

In addition, the 2011 and later surveys utilized a different Fairbanks telephone database that included mobile phones. Given the growing use of cell phones, in some households as a replacement for land-line phones, concern emerged that the approach used to sample households using a land-line only phone number database may have unintentionally biased the resulting samples. As a result, the household selection process for the 2011 and later surveys was revised to include cell-sampled respondents. The cell phone respondents were contacted using known Fairbanks cell prefixes, and then verified to be within the boundaries of the survey. Sample sizes for the cell phone respondent subsets within each survey were "self-selecting." Hays simply used a combined list of phone numbers (land and cell) and randomly dialed from the list. Cell vs. land line phone status was later confirmed by the Hays interviewer during the survey of each respondent. The cell phone respondent fractions ranged from 5% to 12% across the three (2011 and later) HH surveys. No ZIP code or address location data were collected for these cell-based respondents, except within the 2012 survey[11]. For the other surveys, cell respondents were proportionally distributed across the non-attainment area ZIP codes based on the 2010 Census weightings.

Survey Content – The surveys focused on identifying the types and usage practices of different home heating devices used in residences within the nonattainment area during winter months. It was organized into a hierarchical series of roughly 70 separate questions that respondents were asked to answer based on the types of heating devices available and used within their homes. Key questions included the following:

- identifying the types of heating devices present in the household (including the specific type of wood-burning device if used);
- providing rough usage percentages for each device on both a winter season and annual basis; and
- estimating the amount of fuel used in each device (e.g., cords of wood or gallons of heating oil) both during winter and on an annual basis.

The survey questions were organized in a "branching" structure. An initial set of focused questions were asked to identify the types of heating devices present and used in the home. Then for each device applicable to the household, separate branches of further questions were asked about each device. The residential heating device types tracked under the surveys (for which separate question branching was conducted) are listed in Table 5.6-9. The surveyor navigates the homeowner through specific branches of the survey related to those devices that exist in the household. In addition to those devices explicitly listed in Table 5.6-9, the survey allows other types of heating devices to be identified and recorded into a generic "Other" group for which "verbatim" descriptions of the device provided by the homeowner were recorded into a separate file. Generally, the most common type of heating device in the Other category is portable electric heaters, which produce upstream or indirect emissions.

[11] For the 2012 HH survey only, address data were obtained by Hays, but not released. Hays used the addresses to locate the surveyed households within ZIP codes in material provided to ADEC.

Table 5.6-9
Fairbanks Home Heating Survey Device Types

Fuel Group	Device Type
Wood-Burning	Fireplaces
	Woodstoves/Inserts
	Outdoor Wood Boilers
Oil-Burning	Central Oil Boilers/Furnaces
	Portable Fuel Oil/Kerosene Heaters
	Direct Vent Heaters
Gas	Natural Gas Heaters
Coal	Coal Heaters
Steam	Municipal (District) Heat[a]

[s] Municipal or District heat refers to steam heat circulated in underground pipes generated from the Aurora Energy coal plant.

After the branching portions of the each survey are completed for the specific devices present in the home, a general section of questions are included at the end that were asked of all respondents. These questions typically focused on planned changes in heating devices/practices and also included elements related to Borough education and control programs. Summarized separately below are the key types of questions contained in each survey branch or section:

- *Initial Section* - types of devices present in the house and the homeowner's rough estimate of the percentages each device was used during winter (and annually in some surveys), later surveys also asked for dwelling size (heated space);

- *Fireplace Section* – winter season and annual wood use estimates; whether wood used is cut by the homeowner or purchased commercially, seasoning period before burning, estimated wood moisture content and annual wood expenditure;

- *Stove/Insert Section* – estimated age and installation date of device, winter season and annual wood use estimates, cordwood or pellet device, whether wood used is cut or bought, seasoning period before burning, estimated wood moisture content and annual wood expenditure;

- *Outdoor Wood Boiler Section* - winter season and annual wood use estimates, use of cordwood or pellets, whether wood used is cut or bought, seasoning period before burning, estimated wood moisture content and annual wood expenditure;

- *Central Oil Section* – size of fuel tank, gallons of heating oil used during winter and annually, yearly cost of fuel oil;

- *Portable Fuel Oil/Kerosene Heater Section* - similar to Central Oil section, plus questions asking whether the device burns fuel oil or kerosene;

- *Direct Vent Heater Section* – similar to Central Oil section;

- *Gas Section* – estimated winter season and annual expenditures for natural gas;

- *Coal Section* – estimated winter season and annual coal use and expenditure, whether used in indoor stove or outdoor boiler;

- *Municipal Heat Section* - estimated winter season and annual expenditures for municipal (i.e. District) heat; and

- *General/Future Use Section* – this final section included questions about future home heating practices, such as estimating the heating oil price that would trigger each respondent to stop burning wood, as well as questions designed to gauge public awareness about air quality in Fairbanks and wood-burning in particular.

Attachment A contains the interviewer survey script for the 2011 Home Heating survey which lists each of the questions and shows their order and the section branching summarized above.

<u>Survey Data Assembly and Quality Assurance Review</u> – Once the telephone surveys were completed by Hays Research (the survey firm used to conduct the surveys and assemble the response data) the survey data were then provided to ADEC in a series of electronic files[12] for processing and quality assurance review as described below.

Assembly & Processing – For each survey, the as-received data were imported into a single spreadsheet, the primary response data were loaded into on sheet, the verbatim responses in a secondary sheet, with those responses organized into tables specific to each question of that form (verbatim rather than categorical/numeric responses). Each record in the primary data corresponded to completed and coded responses to all questions for a household. Each column contains the responses to a specific question. Respondent IDs survey dates and residence ZIP codes were also listed for each record. (Respondent IDs were also recorded for the verbatim responses so they could be properly linked to the primary data. Other basic processing steps included converting number values to numeric types and reassigning '999' missing data codes used by Hays to blank values within the spreadsheets so they would be properly treated during subsequent statistical tabulations performed in the spreadsheets.

Quality Assurance Review – Before response data were analyzed and tabulated into metrics used within the SIP inventories, a detailed set of data consistency and range checks were performed on the as-received data as provided by Hays. Examples of data consistency checks included

[12] The primary file contains categorical/numeric responses to most of the survey questions. Separate files were used to collect and provide "verbatim" responses to specific questions which did not involve categorical responses. For example, respondents were asked to briefly describe the types of devices that landed into the generic "Other" device category discussed earlier.

comparing devices used in the household recorded in the initial section of the survey with completed, valid responses in the appropriate device-specific "branch" sections, or checking that annual fuel use was always greater than or equal to winter season (Oct-Mar) fuel use.
Range checks were also applied to responses for questions that involved numerical, rather than categorical responses. Plausible or theoretical limits were used to flag "outlier" values for specific questions (e.g., wood stove fuel use). Where possible, flagged values were compared to other related responses for corroboration. For example, fuel use entries (e.g., cords of wood or gallons of oil burned) were compared to responses in the initial section where the homeowner provided roughly percentage distributions of device usage for each equipped device. If there was a large inconsistency between the two elements, the usage data were invalidated. As an example, if a respondent said they burned 10 cords of wood in the winter (very large amount) but listed their wood device providing only 20% of total winter usage, then the wood use entry was marked as invalid.

Most of the response data (generally 80% or higher) passed these consistency and range checks. For those that didn't, inconsistencies were reported to Hays. In some cases, transcription or survey logic errors were discovered. Transcription errors were then corrected. Survey logic errors (where the surveyor forgot to as device specific questions for devices present in a household) were addressed by performing callbacks to specific respondents (or calling additional households when the initial respondents were not available) in order to develop valid samples that met sample size targets of the survey (300 households in 2010 and earlier surveys, 700 households in 2011 and later surveys).

Tabulation of Key Results – A series of basic cross-tabulations were prepared to examine results of the responses to each question in the surveys. Key results from these tabulations are presented separately below for the 2011 Home Heating Survey. (As discussed later, results from the 2011 survey were primarily used in the SIP inventory calculations.)

Households Sample Sizes and Multi-Device Usage - The first step in the analysis consisted of translating the cross-tabulated record counts into fractional or percentage distributions by device or fuel type so the survey results could be applied to update the emissions inventory. As described earlier, the initial section of the survey asked respondents to identify all of the specific type(s) of heating devices used in the household. Thus the survey accounted for use of multiple heating devices within each household. These instances of multiple device use within a household had to be properly accounted for in tabulating the results to ensure that surveyed usage is correctly extrapolated to the entire population of Fairbanks households.

Table 5.6-10 shows the sample sizes by ZIP code (including Cellphone households that could not be located by ZIP) in the first two rows. The number and percentage of sampled households are shown. In the highlighted row below, weighting factors developed from the percentage of households within each ZIP code based on the 2010 U.S. Census are shown. Comparing these weighting factors to the sample percentages just above, the sample percentages are in nominal, but not perfect agreement with the Census-based weightings. As described later, these weightings were used to adjust the sampled response data by ZIP (and unknown ZIP for the cellphone households) to generate Census-weighted composites in addition to sample self-weighted averages.

Table 5.6-10 2011 HH Survey Sample Size and Multiple Use Types								
Parameter	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**
Sample Size, Households	86	181	27	139	214	59	6	**712**
Sample Size, % of Sample	12.1%	25.4%	3.8%	19.5%	30.1%	8.3%	0.8%	**100.0%**
2010 Census Household Weightings	-	24.6%	4.7%	23.9%	34.3%	12.0%	0.5%	**100.0%**
Multi-Type Household Factor	1.56	1.31	1.52	1.58	1.61	1.76	1.33	**1.53**
Multi-Type Household Use %	45.3%	52.5%	37.0%	48.2%	40.7%	50.8%	50.0%	**46.5%**

[a] Also includes Birch Hill area

Next, Table 5.6-10 lists the multiple device usage factors that were calculated from the validated survey data. This "Multi Type Household Factor" represents the ratio of the total number of devices used divided by the number of households. (For example, a factor of 2.0 would indicate an average of two devices in each household.) As seen in Table 5.6-10, there is a fairly consistent multi-type factor across all ZIP codes, with an average for the entire sample of 1.53. Finally, Table 5.6-10 shows the percentages of households with more than one heating device. As shown, over 46% of all surveyed households use multiple heating devices.

Device Counts and Usage Distributions – Table 5.6-11 summarizes the counts (number of households) of heating devices by device type and ZIP code from the survey sample. As seen in Table 5.6-11, central oil furnaces (564 total households) and wood-burning devices (240 total households) were the most commonly found home heating devices in the 712 household survey sample. The totals of all devices reported at the bottom of Table 5.6-11 reflect the fact that many households use more than one type of home heating device. These totaled counts, when divided by the number of households surveyed listed earlier in Table 5.6-10, match the Multi-Type Household Factors also reported in Table 5.6-10 (for example, within the Downtown area, 238 ÷ 181 = 1.31).

Table 5.6-12 presents the distributions of device usage percentages by ZIP code during the winter months (October-March). These usage percentages were determined from the survey responses to Q9a-Q9h where the respondents were asked to roughly estimate the percentage of time each household device is used during winter. The usage percentages in Table 5.6-12 are not based on either the counts of household devices or the amounts of fuel used queried in later sections of the survey. The usage percentages have been properly normalized to account for multiple device use within a household as described in the preceding sub-section. As shown in Table 5.6-12, central oil furnaces are used between 46% and 77% of the time across all ZIP code areas, with an average across the entire sample of 68.0%. Wood-burning devices represent 14.8% of total wintertime device usage across the entire sample, with higher percentages in the outlying areas (North Pole, Airport and Steese) than in those nearer the city center (Downtown, Wainwright and University). As seen in Table 5.6-12, households in the Wainwright/Birch Hill area have a much greater usage of District heating because of access to this underground infrastructure.

Table 5.6-11 2011 HH Survey Counts of Heating Device Types (Number of Surveyed Households with Device)								
Heating Device Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**
Wood Burning	24	30	7	59	92	27	1	**240**
Central Oil Furnace	55	149	15	120	173	47	5	**564**
Portable Heat Device	8	6	2	6	10	3	1	**36**
Direct Vent Type	27	21	5	21	42	13	0	**129**
Natural Gas	6	8	6	3	3	1	1	**28**
Coal Heating	2	2	0	2	2	2	0	**10**
District Heating	2	9	4	1	4	1	0	**21**
Other	10	13	2	8	18	10	0	**61**
TOTALS	**134**	**238**	**41**	**220**	**344**	**104**	**8**	**1089**

[a] Also includes Birch Hill area

The rightmost column of Table 5.6-12 highlights composite average device usage percentages using the 2010 Census household ZIP code weightings listed earlier in Table 5.6-10. These weighted averages were calculated using the Census-based household fractions (rather than the survey sample fractions) by ZIP code. Cell households with no known ZIP code were weighted into the Census composite based on their proportion with the sample (i.e., they were assumed to be proportionally distributed into each ZIP code based on the Census weightings).

Table 5.6-12 2011 HH Survey Distributions of Respondent-Estimated Winter Heating Usage Percentages by Device Type									
Heating Device Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd.**
Wood Burning	13.4%	6.2%	13.0%	22.0%	15.6%	24.1%	13.3%	**14.8%**	**15.4%**
Central Oil Furnace	54.2%	77.0%	45.7%	69.6%	69.9%	60.4%	65.8%	**68.0%**	**67.5%**
Portable Heat Device	1.3%	1.7%	0.3%	0.8%	0.3%	0.1%	4.2%	**0.9%**	**0.8%**
Direct Vent Type	23.0%	5.2%	6.9%	5.0%	10.1%	10.6%	0.0%	**9.2%**	**9.4%**
Natural Gas	4.7%	3.9%	21.5%	0.9%	1.4%	1.7%	16.7%	**3.3%**	**3.2%**
Coal Heating	0.0%	1.1%	0.0%	0.2%	0.9%	0.3%	0.0%	**0.6%**	**0.6%**
District Heating	2.3%	3.9%	12.6%	0.0%	0.5%	0.1%	0.0%	**1.9%**	**1.8%**
Other	1.1%	1.0%	0.1%	1.5%	1.4%	2.7%	0.0%	**1.3%**	**1.4%**

[a] Also includes Birch Hill area

Wood-Burning Device Breakdowns – Despite the fact that the survey indicates wood-burning devices are used less than 20% of the time, they are a significant contributor to wintertime ambient $PM_{2.5}$ levels. Table 5.6-13 lists the breakdowns in the types of wood-burning devices used within each surveyed ZIP code area. As shown, woodstoves represent an overwhelming majority of wood-burning devices in Fairbanks. Over 87% of the wood burning devices according to the Census-weighted survey sample are woodstoves. This is not surprising given their heating efficiency and the ability to locate the stove within the interior of a residence.

Table 5.6-13
2011 HH Survey Distribution of Wood-Burning Devices (Percent of Households Sampled)

Wood-Burning Device Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd.**
Fireplace	4.3%	11.5%	16.7%	3.6%	5.6%	0.0%	0.0%	**5.3%**	**5.3%**
Fireplace with Insert	0.0%	19.2%	0.0%	7.3%	3.4%	3.7%	0.0%	**5.7%**	**4.4%**
Woodstove	82.6%	65.4%	83.3%	83.6%	89.9%	92.6%	100.0%	**85.0%**	**87.1%**
Outdoor Wood Boiler	13.0%	3.8%	0.0%	5.5%	1.1%	3.7%	0.0%	**4.0%**	**3.3%**

[a] Also includes Birch Hill area

As also shown in Table 5.6-13, fireplaces represent most of the remaining wood-burning usage. Those with inserts constitute 4.4% of the overall sample. Fireplaces without inserts, which are extremely energy inefficient for space heating purposes, represent 5.3% of household wood devices. Outdoor boilers were only found in some areas and represent 3.3% of the weighted survey sample.

Table 5.6-14 provides a further breakdown of the splits between un-certified and certified fireplace inserts or woodstoves. It shows that un-certified stoves/inserts represent about one-quarter (25.2%) of the overall sample, although the split varies significantly by ZIP code, possibly the result of small sample sizes for some of the ZIP codes.

Table 5.6-14
2011 HH Survey Splits Between Un-Certified and Certified Fireplace Inserts/Woodstoves (Percent of Households Equipped)

Insert/Woodstove Certification Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd.**
Un-Certified (<1988)	21.1%	23.8%	0.0%	23.9%	26.6%	12.0%	0.0%	**22.4%**	**25.2%**
Certified (≥1988)	78.9%	76.2%	100.0%	76.1%	73.4%	88.0%	100.0%	**77.6%**	**74.8%**

[a] Also includes Birch Hill area

These splits were compiled based on the responses to Q10a of the survey: "*Was your woodstove or insert installed before or after 1988?*" Beginning in 1988, EPA set mandatory New Source

Performance Standards (NSPS) [13] for new woodstoves and inserts. Smoke emission levels of 1988 and newer stoves meeting these EPA limits are generally 50-80% lower than from older un-certified units, so the split between un-certified and certified stoves has a significant effect on particulate emissions.

This survey question based on the device installation date may not truly represent the split between EPA-certified and uncertified devices. Even though EPA established these NSPS, regulatory implementation still enabled device manufacturers to sell "woodstove-like" devices that were not subject to the NSPS. As described in the following sub-section, a specialized survey was conducted in 2013 to identify and quantify the fractions of these additional stove-like devices in use in Fairbanks that avoided NSPS certification.

Fuel Usage Rates and Costs - Table 5.6-15 summarizes average fuel usage rates (i.e., the amount of fuel used per season or year) and heating costs by device type for households equipped with or using each device/fuel. These are not averages across all households.

Table 5.6-15
2011 HH Survey Wood Burning, Heating Oil and Other Fuel Usage Rates and Heating Costs per Equipped Household

Device Type	Usage Period	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd.**
Stove/Insert Wood Use (cords)	Annual	3.73	2.80	4.60	4.13	3.13	4.48	2.23	**3.57**	**3.54**
	Winter	3.56	2.50	4.00	3.59	2.82	3.95	2.00	**3.19**	**3.17**
Fireplace Wood Use (cords)	Annual	1.00	4.00	n/a	n/a	1.33	n/a	n/a	**1.80**	**2.27**
	Winter	1.00	4.00	n/a	n/a	1.00	n/a	n/a	**1.60**	**2.10**
Outdoor Wood Boiler Use (cords)	Annual	18.00	n/a	n/a	19.67	30.00	2.00	n/a	**18.14**	**21.25**
	Winter	11.33	7.00	n/a	19.67	30.00	2.00	n/a	**14.67**	**16.29**
Central Oil Use (gal)	Annual	1,225	1,444	1,156	1,207	1,125	1,497	800	**1,261**	**1,263**
	Winter	803	1,097	940	936	954	1,061	650	**977**	**972**
Portable Heater Fuel Use (gal)	Annual	267	508	40	607	60	118	n/a	**253**	**303**
	Winter	237	358	40	574	53	118	n/a	**216**	**258**
Direct Vent Heater Fuel Use (gal)	Annual	460	421	75	543	337	779	n/a	**436**	**450**
	Winter	400	392	70	488	278	719	n/a	**383**	**400**
Natural Gas Fuel Cost (dollars)	Annual	$2,275	$3,900	$1,725	$1,267	$2,300	$400	n/a	**$2,481**	**$2,202**
	Winter	$1,606	$2,783	$1,225	$733	$1,650	$400	n/a	**$1,692**	**$1,548**
District Heat Fuel Cost (dollars)	Annual	$144	$1,700	$229	n/a	$4,833	$200	n/a	**$1,727**	**$2,474**
	Winter	$105	$540	$167	n/a	$4,667	$200	n/a	**$1,258**	**$2,067**

[a] Also includes Birch Hill area
n/a – Not applicable (i.e., indicates where a device was not found in the sample for a specific ZIP code)

As shown in Table 5.6-15, households using either fireplaces with inserts or woodstoves burn an average of 3.54 cords annually and 3.17 cords of wood during winter months (October through

[13] EPA certified woodstove smoke emission limits are 7.5 grams/hour and 4.1 grams/hour for non-catalytic and catalytic devices, respectively (http://www.epa.gov/burnwise/woodstoves.html)

March) across the weighted survey sample. (These averages were compiled from a sample size of 206 households using fireplaces with inserts or woodstoves.) As also shown in Table 5.6-15, households equipped with fireplaces (without inserts) burned less, using 2.27 and 2.10 cords annually and in winter, respectively. This is not surprising given the significantly lower net heating efficiency of standard fireplaces compared to those with inserts or woodstoves. In contrast wood usage for outdoor wood boilers (OWBs) was much higher, averaging over 16 cords during winter. Although the sample size of OWB households in this survey was small (9 respondents), higher wood usage for these devices is consistent with the fact that they are generally used as a primary, rather than supplemental heating source.

As reported in Table 5.6-15, households using central oil furnaces consume an average of 1,263 gallons of heating oil annually and 972 gallons during winter months alone. (These averages are based on a total of 564 central oil furnaces identified in the survey.)

Table 5.6-15 also lists similarly tabulated average fuel amounts or costs for portable/kerosene heaters, direct vent heaters, natural gas-based heating, and municipal heating. The sample sizes these device-specific averages were tabulated from were generally much smaller than for wood-burning and central heating devices. As such, they should be interpreted with caution.

Extrapolation of Survey Sample to Nonattainment Area – An important element of the analysis consisted of extrapolating heating device counts and usage rates from the sample of 712 surveyed households to the entire household population within the Fairbanks $PM_{2.5}$ nonattainment area. The extrapolation was based on the 2010 U.S. Census-based occupied household counts by ZIP code within the nonattainment area. These Census-based household counts within the nonattainment area are listed in the first row of Table 5.6-16. Based on the share of Cell households in the survey sample, these Census counts were proportionally re-distributed to reflect this Cell share as shown in the second row of Table 5.6-16.

Extrapolation factors or multipliers were then calculated from the number of households in an area (either an individual ZIP code or the entire area) from the Cell-Distributed counts divided by the surveyed households for the same area. For example, the Downtown ZIP code (99701) area contains 6,517 households as listed in Table 5.6-16. Since a total of 181 households within that ZIP code were surveyed as reported earlier in Table 5.6-10, the calculated extrapolation factor is 36.00 (6,517 ÷ 181).

Table 5.6-16 presents these extrapolated estimates of the number of heating devices by ZIP code area and across the entire Fairbanks $PM_{2.5}$ nonattainment area. The first row in the table lists the extrapolation factors calculated for each area to expand the survey sample to the entire population of households for each area. The remaining rows of the table present estimated counts of the number of devices by device type and ZIP code. The "short code" designations in the Device Type column of Table 5.6-16 identify each unique device type and clarify the sub-categories and sub-totals reported within the wood-burning sector. As explained below Table 5.6-16, Electric Heat device counts were also broken out from the Other category.

Table 5.6-16
2011 HH Survey Extrapolated Survey Heating Device Counts to $PM_{2.5}$ Nonattainment Area

Device Type	Cell	Dntown	Wnwrt[a]	Nth Pole	Airport	Steese	Univ	**$PM_{2.5}$ NA Area**

	No ZIP	99701	99703	99705	99709	99712	99775	**ZIP Sum**	**Extrap**
Census-Based Households	*n/a*	*7,412*	*1,490*	*7,560*	*11,430*	*4,199*	*2*	***32,093***	***32,093***
Cell-Distributed Households	*3,876*	*6,517*	*1,310*	*6,647*	*10,049*	*3,692*	*2*	***32,093***	***32,093***
Extrapolation Factor	*45.07*	*36.00*	*48.52*	*47.82*	*46.96*	*62.57*	*0.29*	***n/a***	***45.07***
1 - Wood-Burning Device	1,082	1,080	340	2,821	4,320	1,689	0	**11,333**	**10,818**
1a - Fireplace without insert	47	125	57	103	243	0	0	**574**	**572**
1b - Fireplace with insert	0	208	0	205	146	63	0	**621**	**620**
1c - Woodstove	894	706	283	2,360	3,883	1,564	0	**9,691**	**9,198**
Stoves & Inserts (1b+1c)	894	914	283	2,565	4,029	1,627	0	**10,312**	**9,817**
Stove/Ins, Uncertified	188	218	0	613	1,071	195	0	**2,285**	**2,183**
Stove/Ins, Certified	706	696	283	1,952	2,958	1,432	0	**8,026**	**7,634**
Stove/Ins, Cord Wood	800	914	226	2,360	3,980	1,562	0	**9,842**	**9,427**
Stove/Ins, Pellets	94	0	57	205	49	65	0	**470**	**390**
1d - Outdoor Wood Boiler	141	42	0	154	49	63	0	**448**	**429**
2 - Central Oil Furnace	2,479	5,365	728	5,738	8,124	2,941	1	**25,376**	**25,422**
3 - Portable Heater	361	216	97	287	470	188	0	**1,618**	**1,623**
4 - Direct Vent Heater	1,217	756	243	1,004	1,972	813	0	**6,006**	**5,815**
5 - Natural Gas Heating	270	288	291	143	141	63	0	**1,197**	**1,262**
6 - Coal Heat	90	72	0	96	94	125	0	**477**	**451**
7 - District Heat	90	324	194	48	188	63	0	**906**	**947**
8 – Electric Heat[b]	180	180	49	0	282	188	0	**878**	**856**
9 - Other	270	288	49	383	564	438	0	**1,991**	**1,893**
All Heating Devices	894	914	283	2,565	4,029	1,627	0	**49,783**	**49,086**

[a] Also includes Birch Hill area

[b] Electric Heat households and extrapolated device counts developed from processing verbatim responses with "Other" generic device group in survey responses. The "Other" counts shown below this row reflect all non-electric heat devices listed as Other in the survey.

The extrapolation of device counts from the survey sample to total households across the entire nonattainment area was performed two different ways: (1) by individual ZIP code and then summed; and (2) for the entire self-weighted sample. Table 5.6-16, these total device counts for the nonattainment area are reported in the two rightmost columns labeled "ZIP Sum" and "Extrap," respectively. As seen in comparing these columns, the counts differ slightly. This is likely due to propagation of round-off error from small sample sizes within each ZIP code when summed across all ZIP code areas reflected in the survey sample.

On this basis, a total of 11,333 wood-burning devices were estimated to be in use within the nonattainment area. Of these, 9,691 are free-standing woodstoves and 621 are fireplaces with inserts. From the combined total of 10,312 stoves/inserts, 2,285 were estimated to be un-certified (pre-1988). Fireplaces without inserts and outdoor wood boilers represent the remaining wood-burning devices; their counts within the nonattainment area are 574 and 448, respectively, as shown in Table 5.6-16. As addressed below, the precision of device count estimates are not necessarily accurate to the whole integer values listed in Table 5.6-16. The whole integer values are simply shown in this table to illustrate how they were calculated from the sample-to-nonattainment area extrapolation factors.

Statistical Uncertainty Analysis – In extrapolating devices counted in the 2011 HH survey sample to the entire nonattainment area, an additional issue that was addressed was the resulting statistical uncertainty. As shown in the preceding tables, very small numbers of households with certain devices were found. Thus, an analysis of the uncertainties associated with proportional extrapolation of the household sample to the entire nonattainment area was performed.

The results of this uncertainty analysis are presented in the next three tables. The estimates in these tables quantify the statistical uncertainty associated with extrapolating the device usage distributions in the surveyed sample represented earlier in Table 5.6-12 through Table 5.6-14 to all the households in the nonattainment area. In each of these tables, the standard error of proportion was used as the measure of statistical uncertainty. It represents the accuracy of each proportional (i.e., usage fraction) estimate in the sample, measured as the standard deviation of that proportion.

First, Table 5.6-17 presents standard errors of proportion associated with the respondent-estimated usage fractions of each major device type reported earlier in Table 5.6-12. The first value in each cell is the usage fraction from Table 5.6-12; the second value represents one standard deviation of this usage fraction. For example, the fraction of wood-burning devices used in winter for the entire sample was 17.2% (as listed earlier in Table 5.6-12). Assuming device usage is normally distributed, the value of ±1.4% listed in the upper right cell in Table 5.6-17 means that the actual wood-burning usage fraction lies between 14.0% (15.4 - 1.4) and 16.8% (15.4 + 1.4) with 68% probability.[14]

As expected, the usage fraction estimates within individual ZIP code areas have wider ranges of standard error than the overall estimate across all areas because the standard error estimates are related to sample size. As seen in the rightmost column in Table 5.6-17, the standard errors for heating device usage fraction are less than ±2% across the entire nonattainment area.

Similarly, Table 5.6-18 and Table 5.6-19 present Standard Error of Proportion estimates for proportional device usage within the wood-burning sector and between un-certified and certified woodstoves/inserts, respectively.

[14] 68% probability represents the probability of a normally-distributed sample within one standard deviation of its mean.

Table 5.6-17
2011 HH Survey Standard Error of Proportion for
Respondent-Estimated Winter Heating Usage Percentages by Device Type

Heating Device Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd**
Wood Burning	13.4% ±3.7%	6.2% ±1.8%	13.0% ±6.5%	22.0% ±3.5%	15.6% ±2.5%	24.1% ±5.6%	13.3% ±13.9%	**14.8% ±1.3%**	**15.4% ±1.4%**
Central Oil Furnace	54.2% ±5.4%	77.0% ±3.1%	45.7% ±9.6%	69.6% ±3.9%	69.9% ±3.1%	60.4% ±6.4%	65.8% ±19.4%	**68.0% ±1.7%**	**67.5% ±1.8%**
Portable Heat Device	1.3% ±1.2%	1.7% ±1.0%	0.3% ±1.0%	0.8% ±0.7%	0.3% ±0.3%	0.1% ±0.3%	4.2% ±8.2%	**0.9% ±0.3%**	**0.8% ±0.3%**
Direct Vent Type	23.0% ±4.5%	5.2% ±1.7%	6.9% ±4.9%	5.0% ±1.8%	10.1% ±2.1%	10.6% ±4.0%	n/a	**9.2% ±1.1%**	**9.4% ±1.1%**
Natural Gas	4.7% ±2.3%	3.9% ±1.4%	21.5% ±7.9%	0.9% ±0.8%	1.4% ±0.8%	1.7% ±1.7%	16.7% ±15.2%	**3.3% ±0.7%**	**3.2% ±0.7%**
Coal Heating	n/a	1.1% ±0.8%	n/a	0.2% ±0.4%	0.9% ±0.6%	0.3% ±0.7%	n/a	**0.6% ±0.3%**	**0.6% ±0.3%**
District Heating	2.3% ±1.6%	3.9% ±1.4%	12.6% ±6.4%	0.0% ±0.1%	0.5% ±0.5%	0.1% ±0.4%	n/a	**1.9% ±0.5%**	**1.8% ±0.5%**
Electic Heating	1.1% ±1.1%	1.0% ±0.7%	0.1% ±0.5%	1.5% ±1.0%	1.4% ±0.8%	2.7% ±2.1%	n/a	**1.3% ±0.4%**	**1.4% ±0.4%**
Other	13.4% ±3.7%	6.2% ±1.8%	13.0% ±6.5%	22.0% ±3.5%	15.6% ±2.5%	24.1% ±5.6%	13.3% ±13.9%	**14.8% ±1.3%**	**15.4% ±1.4%**

[a] Also includes Birch Hill area
n/a – Not available

Table 5.6-18
2011 HH Survey Standard Error of Proportion for
Distribution of Wood-Burning Devices (Percent of Households Sampled)

Wood-Burning Device Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd**
Fireplace	4.3% ±4.2%	11.5% ±6.3%	16.7% ±15.2%	3.6% ±2.5%	5.6% ±2.4%	n/a	n/a	**5.3% ±1.5%**	**5.3% ±1.5%**
Fireplace with Insert	n/a	19.2% ±7.7%	n/a	7.3% ±3.5%	3.4% ±1.9%	3.7% ±3.6%	n/a	**5.7% ±1.5%**	**4.4% ±1.4%**
Woodstove	82.6% ±7.9%	65.4% ±9.3%	83.3% ±15.2%	83.6% ±5.0%	89.9% ±3.2%	92.6% ±5.0%	100.0% ±0.0%	**85.0% ±2.4%**	**87.1% ±2.2%**
Outdoor Wood Boiler	13.0% ±7.0%	3.8% ±3.7%	n/a	5.5% ±3.1%	1.1% ±1.1%	3.7% ±3.6%	n/a	**4.0% ±1.3%**	**3.3% ±1.2%**

[a] Also includes Birch Hill area
n/a – Not available.

Table 5.6-19
2011 HH Survey Standard Error of Proportion for
Un-Certified and Certified Stove/Insert Splits (Percent of Households Equipped)

Insert/Woodstove Certification Type	Cell No ZIP	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**	**Census Wtd**
Un-Certified (<1988)	21.1% ±9.4%	23.8% ±9.1%	n/a	23.9% ±6.0%	26.6% ±4.9%	12.0% ±6.4%	n/a	**22.4% ±3.7%**	**25.2% ±4.0%**
Certified (≥1988)	78.9% ±9.4%	76.2% ±9.1%	100.0% ±0.0%	76.1% ±6.0%	73.4% ±4.9%	88.0% ±6.4%	100.0% ±0.0%	**77.6% ±13.0%**	**74.8% ±12.0%**

[a] Also includes Birch Hill area
n/a – Not available.

Comparisons Across Surveys – Finally, Table 5.6-20 presents a comparison of key tabulations from each of the historical Fairbanks Home Heating surveys: 2006, 2007, 2010, 2011 and 2012.[15] The tabulations from all the historical surveys were re-weighted by ZIP code using the 2010 Census weightings for consistency when comparing results.

As Table 5.6-20 shows, the normalized fractions of winter device are fairly consistent over time, except for the fact that wood use fractions have headed upward while usage in the generic Other category has trended down. It shows that wood stoves, and recently, outdoor wood boilers have exhibited increased usage within the wood-burning device sector. A large downward trend in the fraction of uncertified stoves/inserts can also be seen in Table 5.6-20.

Table 5.6-20 also shows increasing (but still modest) penetration of pellet-burning stoves, rising from near zero in the 2006 and 2007 surveys to roughly 4% of total stoves/inserts in the three latter surveys.

In addition, the "Wood Source" section of Table 5.6-20 shows how the mix of where households acquire their wood has trended over time. Most wood-burning households cut their own wood (vs. purchasing it commercially), although the "Cut Own" fraction appears to have drifted downward in recent surveys as shown in Table 5.6-20.

Finally as shown in the lower section of Table 5.6-20, winter season fuel use and heating cost trends are mixed across the list of devices shown. Although both wood stove/insert and fireplace usage in households equipped with those devices have trended upward, there is significant year to year oscillation in the averages compiled from the survey data.

As highlighted in Table 5.6-20, the 2011 survey data were largely used in the baseline (2008) inventory as well as for the projected baseline inventories (through 2019) although several options were considered as follows. Initially, thought was given to extrapolating estimates to 2008 using key results (e.g. usage splits) from the 2007 and 2010 surveys. This was

[15] Although data were also collected under a 2013 Home Heating Survey, they have yet to be fully validated and processed as described earlier in this section. Thus, only comparisons/trends through the 2012 survey are shown.

Table 5.6-20
Summary of Key Results from Historical Home Heating Surveys (through 2012)

Statistic	Parameter	Survey Results				
		2006[a]	2007[a]	2010	2011	2012
Average Winter Device Use by Type (% of Household Use)	Wood	10.8%	12.4%	18.2%	15.4%	19.1%
	Central Oil	68.6%	64.8%	67.2%	67.5%	68.2%
	Portable	0.7%	0.5%	0.1%	0.8%	0.1%
	Direct Vent	8.1%	7.0%	8.0%	9.4%	6.9%
	Natural Gas	2.4%	2.0%	4.2%	3.2%	3.0%
	Coal Heat	n/a	n/a	0.5%	0.6%	0.4%
	District Heat	2.0%	0.8%	1.1%	1.8%	1.9%
	Electric Heat	n/a	n/a	n/a	0.0%	0.1%
	Other	7.5%	12.5%	0.8%	1.4%	0.3%
Wood Burning Type (% of Wood-Burning Devices)	Fireplace	12.6%	17.1%	7.0%	5.3%	4.2%
	Fireplace + Insert	8.2%	5.6%	6.1%	4.4%	4.0%
	Woodstove	79.2%	77.2%	85.3%	87.1%	89.1%
	Wood Boiler	n/a	n/a	1.6%	3.3%	2.7%
Wood Stove/Insert Cert Type (% of Woodstoves/Inserts)	<1988 (Un-Certified)	52.0%	46.7%	35.7%	25.2%	22.8%
	≥1988 (Certified)	48.0%	53.3%	64.3%	74.8%	77.2%
Wood Stove/Insert Wood Type (% of Woodstoves/Inserts)	Cordwood	99.8%	100.0%	95.8%	96.7%	95.9%
	Pellet	0.2%	0.0%	4.2%	3.3%	4.1%
Wood Stove/Insert Wood Source (% of Woodstoves/Inserts)	Buy	27.0%	28.0%	36.5%	26.8%	36.2%
	Cut Own	71.1%	60.6%	50.2%	62.1%	49.0%
	Both (Buy & Cut)	1.8%	11.4%	13.4%	11.1%	14.8%
Stove/Insert Wood Use (cords), Winter	Winter Season	3.14	2.84	3.51	3.17	3.68
Fireplace Wood Use (cords), Winter	Winter Season	0.82	0.81	4.09	2.10	2.76
Central Oil Use (gallons), Winter	Winter Season	1,172	1,027	819	972	874
Portable Heater Fuel Use (gallons), Winter	Winter Season	97.1	241.9	59.1	257.8	22.5
Direct Vent Heater Fuel Use (gallons), Winter	Winter Season	470	514	487	400	383
Natural Gas Heating Fuel Cost (dollars), Winter	Winter Season	$1,414	$1,287	$1,346	$1,548	$1,622
Municipal Heating Fuel Cost (dollars), Winter	Winter Season	$70	n/a	$1,452	$2,067	$1,112

[a] Winter usage in these surveys encompassed October-May; later survey winter usage spanned October-March.

rejected in favor of simply using the 2011 results to represent 2008 conditions for two reasons. First, the 712-household sample size was more than double that of the prior surveys (~300 households). Second, the 2011 survey specifically targeted cellphone households while prior surveys used land line-only phone databases to select and contact residents which may have biased results from those surveys.

For the projected baseline inventories beyond 2008, consideration was given to using the 2012 survey data given that it showed a "renewed" upward trend in normalized wood device usage compared to 2011 (19.1% vs. 15.4%) and usage per equipped household (3.68 cords vs. 3.17 cords) as shown earlier in Table 5.6-20. However, looking at the range in year-to-year variations of key metrics across the surveys seen in Table 5.6-20, it wasn't clear if the 2012 results represented a persistent upward wood use trend, or just sample variation. Ultimately, a decision was made to use the 2011 data to represent projected baseline conditions with one exception explained below. The State plans to continue these annual home heating surveys and if they show a sustained upward shift in wood use, those results would be reflected in future SIP projected baselines.

The key exception to use of the 2011 data for the projected baseline inventories was the clear downward trend in the fraction of uncertified wood stoves and inserts, dropping from 52.0% in 2006 to 22.8% in 2012 as shown earlier in Table 5.6-20. Although as discussed in the Control Program section of the SIP, the Borough began a program to change out older, uncertified stoves/inserts in mid-2010, "natural" turnover in stoves from uncertified to newer, certified (and cleaner) stoves clearly preceded the effects of the Borough program. Thus as described in further detail later in the "Survey Data Use in SIP Inventories" sub-section, this downward trend in uncertified stoves/inserts was developed using data from all available Home Heating surveys.

Specialized Wood-Burning Household Surveys

In additional the annual Home Heating surveys described in the preceding section, ADEC and the Borough also commissioned two specialized surveys in early 2013 that focused on wood-burning devices and practices. Unlike the Home Heating surveys which randomly sampled all residential households, these specialized surveys targeted only wood-burning households and are summarized as follows:

1. *Wood Tag Survey* – A telephone survey of 216 households in which respondents were asked a series of questions about their wood devices related to establishing whether it was certified or not and if so, what emission rating (in grams/hour) and output (in BTU/hour) were stamped on the device's "tag" or certification label. Information was also collected on the make, model and installation date of the devices (when available) that was used in conjunction with EPA's published lists of certified stoves/inserts[16] and hydronic heaters[17] to look up emission ratings, technology type (catalytic vs. non-catalytic) and energy output. The survey also contained specific questions related to current participation in wood-related emission control programs, including existing Borough programs as well as likelihood of switching to natural gas under expanded availability of natural gas anticipated over the next several years. Finally, the survey also included questions about other devices and usages within the household beyond the wood-burning devices upon which the survey was primarily focused. As with the Home Heating surveys, the sampling was performed in a stratified manner, randomly sampling households within nonattainment area ZIP codes based on targeted sample sizes developed from 2010 Census household weightings by ZIP code.

[16] http://www.epa.gov/Compliance/resources/publications/monitoring/caa/woodstoves/certifiedwood.pdf
[17] http://www.epa.gov/burnwise/owhhlist.html

2. *Wood Purchase Survey* – A separate survey of 217 wood-burning households within the nonattainment area (again with 2010 Census-weighted targeted sampling by ZIP code) was conducted to ascertain more detailed information about patterns in households that commercially purchase their wood and that cut it themselves. Much like the branching elements of the Home Heating surveys, specific sets of questions were asked in households that bought wood from those that cut their own. For wood buyers, questions centered around purchased wood: the supplier and their reasons for using them, whether wood was split or in rounds or whole logs, etc. For respondents who cut their wood, questions included the source (private or public land), whether a permit was obtained, etc. For both wood source types, respondents were also asked questions related to moisture content and the drying/seasoning period for their wood.

In addition to the specific questions asked within each of these two wood-burning surveys, respondents in both surveys were asked a series of questions about the price premium they would be willing to pay for purchased of pre-dried wood given that dry wood typically produces about 25% more heat per cord than wet wood. These questions were intended to gauge interest and potential participation in a local control program designed to expand use of fully-dry wood.

Attachment A lists the survey script and questions contained in the 2013 Wood Tag and Wood Purchase surveys (following the Home Heating survey script).

<u>Key Findings Across Tag and Purchase Surveys</u> – Before summarizing findings from the unique questions within each specialized wood household survey, tabulations of several key results <u>common</u> to both surveys are presented as follows.

Wood-Burning Device Distributions – Table 5.6-21 presents a side-by-side comparison of the mix of primary wood-burning devices used in sampled households from the Tag and Purchase surveys (each with sample sizes of over 200 households as noted earlier). As shown, distributions of wood devices between the two surveys are in general agreement.

Both surveys show that woodstoves represented well over 80% of primary wood-burning devices. (Pellet and cordwood stoves from the Tag survey totaled 87.8%, these splits were not available from the Purchase survey.). This is consistent with woodstove fractions from the Home Heating surveys shown earlier in Table 5.6-13 and Table 5.6-20. However, the 17.7% pellet stove fraction from the 213 Tag survey was noticeably higher than that observed in more recent Home Heating surveys (which averaged roughly 4%).

Both the Tag and Purchase surveys also exhibited slightly higher fractions of fireplaces, 7.8% and 9.5%, respectively than those seen in recent Home Heating surveys (roughly 5%), although higher fireplace fractions were seen in earlier surveys prior to 2010 as reported in earlier Table 5.6-20.

Table 5.6-21 2013 Wood Survey Wood-Burning Device Distributions (Percent of Households Sampled, Census Weighted)		
Wood-Burning Device Type	Wood Tag Survey	Wood Purchase Survey
Woodstove (cordwood)	70.1%	82.1%
Woodstove (pellet)	17.7%	
Fireplace Insert	0.4%	3.4%
Fireplace (no insert)	7.8%	9.5%
Outdoor Wood Boiler	3.6%	3.2%
Other	0.5%	1.7%

Wood Source Mix - Table 5.6-22 compares the splits in the source of household wood between the Tag and Purchase surveys. As shown, these splits are very consistent, with households that cut their own wood outnumbering those that purchase their wood commercially by about a 3-to-1 margin, with roughly 15-20% of sampled homes using a mixture of purchased and personally harvested wood. This relative 3-to-1 ratio of Cut vs. Buy group households represents a higher split of Cut households than reported from recent Home Heating surveys. As shown earlier in Table 5.6-20, the Cut vs. Buy household splits ranged from 1.5 to 2-to-1 in the 2010-2012 Home Heating surveys.

As explained later in the "Fairbanks Wood Energy and Moisture Content" section of this appendix, the Buy vs. Cut wood source splits are important because of evidence that indicates homeowners that cut their own wood tend to season (and dry) it longer than those who buy their wood. Thus this split affects the overall wood moisture level.

Table 5.6-22 2013 Wood Survey Wood Source Mix (Percent of Households Sampled, Census Weighted)		
Wood Source Group	Wood Tag Survey	Wood Purchase Survey
Buy	22.4%	19.9%
Cut Own	63.1%	57.7%
Both (Buy & Cut Own)	14.5%	22.3%

Cost of Firewood – In both the Tag and Purchase surveys, respondents in the Buy group (those that purchased some or all of their firewood) were also questioned about the price they paid (excluding any delivery fee). The results were very consistent across both surveys and are listed as follows.

Survey	Avg. Price ($/cord)	Range	Sample Size
Tag	$233	$100-$400	50
Purchase	$227	$89-$400	60

In these 2013 surveys, the average price paid for firewood was about $230 per cord (excluding delivery fee). Under the Purchase survey, Buy group respondents were also asked about delivery fees. About 72% paid no delivery fee (or picked up the wood themselves). For the remaining 28% that paid a fee, the average was $293 although values varied from $40 to $700 and the phrasing of the question was vague in specifying the price per cord, delivery or season.

Willingness to Pay More for Dried Wood – Both wood surveys also included a series of questions intended to measure willingness to spend more on commercially-purchased wood that is fully dried before being sold. The questions were identically phrased in both surveys and were directed to those households that buy all or a portion of their firewood. They were asked in a staged manner as follows: *"Knowing that dry wood provides 25 percent more heat than wet wood, would you pay $25 more per cord for dry wood?"* For those who answered yes, the question was then repeated with the threshold raised to $50, then $75, and finally $100.

Responses are summarized in Table 5.6-23. For each staged question, the percentage who responded affirmatively is shown. In parenthesis next to each percentage is the ratio that was used to calculate it (number answering "yes" divided by total definitive answers). The table shows that the percentage of people willing to pay each specified amount for dry wood was fairly consistent between both the Tag and Purchase surveys, but in no case was the difference statistically significant at the 95% confidence level.[18] Thus, the data from two surveys were combined in the rightmost column of Table 5.6-23 to provide the most robust estimate of the surveyed responses (129 combined households that buy wood).

Table 5.6-23
2013 Wood Survey Willingness to Pay for Dry Wood
Distribution of Wood-Burning Devices (Percent of Households Sampled)

Pay More for Dry Wood?	% Willing to Pay (#yes/total)		**Willingness to Pay Combined Surveys**
	Wood Tag Survey	Wood Purchase Survey	
$25/cord more	73.5% (36/49)	72.5% (58/80)	**72.8%**
$50/cord more (if 'yes' to above)	38.6% (17/44)	46.5% (33/71)	**43.5%**
$75/cord more (if 'yes' to above)	16.3% (8/44)	13.6% (9/66)	**15.5%**
$100/cord more (if 'yes' to above)	14.6% (7/43)	4.6% (3/65)	**9.3%**

[18] In general, large sample sizes are necessary to detect small differences between two percentages (see, for example, Snedecor et al, Statistical Methods, 1980).

Key Tag Survey Findings – As noted earlier, the Tag survey sampled 216 wood-burning households in the Fairbanks nonattainment area. The primary objective of the survey was to obtain a reasonably size subset of households with certified woodstoves/fireplace inserts (or Phase 1 or 2-qualified outdoor wood boilers) and have respondents provide certification information about the device such as its smoke rating (particulate emission rate in grams/hour), heating efficiency and heat output (BTU/hour) by reading these data from the certification label or "Tag" stamped on the device. Table 5.6-24 lists the distribution of primary wood-burning devices from the surveyed sample in the "All" column. For each device, it also shows the breakdown between devices identified as uncertified/unknown or EPA-certified based on the respondents answers to the question: *"Is your device certified, or does it have a certification label?"* (Certification label information was only solicited for woodstoves, inserts and outdoor wood boilers. As noted with "n/a" in the "Certified" column of Table 5.6-24, certification data was not applicable to fireplaces or other devices not explicitly identified.)

Table 5.6-24
2013 Tag Survey Wood-Burning Device Distributions
(Number of Households)

Wood-Burning Device Type	Sample Size			
	All	Uncertified/ Unknown	Certified	**Certified, Label Read**
Woodstove (cordwood & pellet)	189	92	97	**18**
Fireplace Insert	1	1	0	
Fireplace (no insert)	17	17	n/a	**n/a**
Outdoor Wood Boiler	8	3	5	**1**
Other	1	1	n/a	**n/a**
Totals	216	114	102	**19**

As shown in the highlighted "Certified, Label Read" column in Table 5.6-24, once respondents were asked to actually read information from the device certification label (or provide via follow-up postcard solicitations) few could or did. Label visibility or access were likely the primary factors for getting few "Label Read" responses.

Fortunately, respondents were also asked to provide make, model and model year of their woodstoves, inserts or outdoor wood boilers. A total of 95 respondents were able to provide this information. These responses (where available) were then compared to EPA's published lists[19] of certified woodstoves/inserts and outdoor hydronic heaters (i.e. outdoor wood boilers). For devices that could be matched to EPA's lists (and are therefore certified), emission rate, efficiency and heat output data were looked up. Using this approach, the initial sample of 19 devices for which complete label data were available was expanded to a total of 68 certified devices (67 stoves/inserts, 1 outdoor wood boiler) with compiled emission rate, efficiency and heat output data.

[19] http://www.epa.gov/burnwise/appliances.html, circa January 2013.

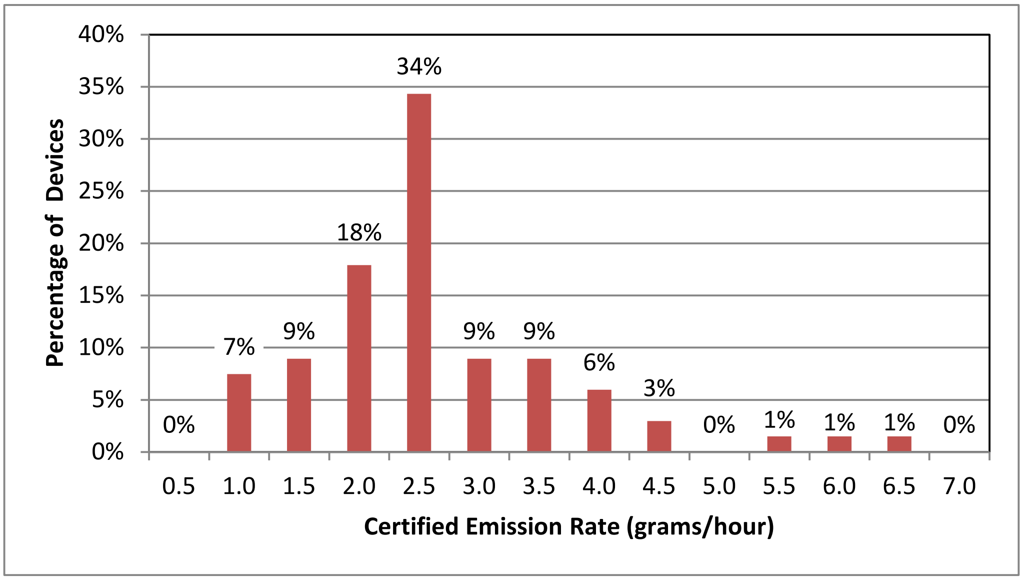
Certified Woodstove/Insert Levels - Table 5.6-25 presents tabulated emission rates (in grams/hour) and heat output ranges (in BTU/hour) for those woodstoves/inserts for which certification data were available. Separate sample sizes and averages are shown by technology type (catalytic vs. non-catalytic). As shown, the analysis sample was split roughly 60%/40% for catalytic and non-catalytic certified woodstoves/inserts. Average particulate emission rates (i.e. certified smoke rating) are highlighted in the middle column. Across the entire sample, the average PM emission rate was found to be 2.48 grams/hour as shown at the bottom of Table 5.6-25. Based on this sample, Fairbanks certified woodstoves/inserts are quite clean compared to EPA's existing certified woodstove emission standards of 7.5 grams/hour and 4.1 grams/hour for non-catalytic and catalytic devices, respectively.

Table 5.6-25
2013 Tag Survey Certified Woodstove/Insert Emission Rates and Output by Technology Type

Technology Type	Sample Size		**Avg. Emission Rate (grams/hour)**	Avg. Output (BTU/hour)	
	N	Pct.		Minimum	Maximum
Catalytic	40	59.7%	**2.23**	10,740	36,541
Non-Catalytic	27	40.3%	**2.86**	10,871	34,714
Totals/Averages	67	100.0%	**2.48**	10,793	35,805

Figure 5.6-28 shows the distribution of emission rates for the certified stoves/inserts from the Tag survey sample. Each interval shows the percentage of devices in the survey sample between the indicated rate and that to its immediate left. For example, 34% of the devices (23 out of 67) had certified emission rates of 2.0 to 2.5 grams/hour. Summing the frequencies from Figure 5.6-28 cumulatively, 31% and 66% of the stoves/inserts were below 2.0 gram/hour and 2.5 gram/hour levels, respectively.

Figure 5.6-28
Distribution of Tag Survey Certified Stove Emission Rates (grams/hour)

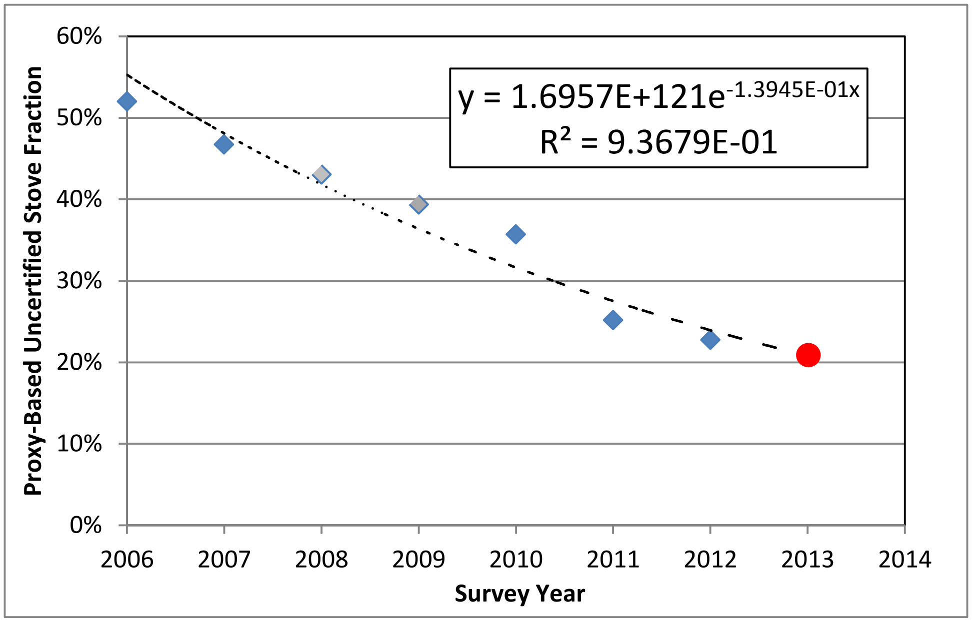


True Uncertified Device Fraction – Responses to specific questions from the Tag survey were also used to evaluate what is believed to be a biased (low) estimate of the percentage of uncertified woodstoves/inserts from the Home Heating surveys. As discussed earlier, the Home Heating surveys do not attempt to get respondents to examine their wood devices for the presence (or absence) of an EPA certification label. The installation date question (1988 and earlier vs. post-1988) from the Home Heating surveys is used as a "proxy" to estimate the fractions of woodstoves/inserts that are not EPA-certified, but as discussed earlier "woodstove-like" devices that are excluded from EPA's wood heater regulations have been observed for sale in Fairbanks retail outlets. Thus, the more definitive label information (or lack thereof) from the Tag survey presented an opportunity to estimate a true uncertified woodstove/insert fraction.

Out of 128 definitive responses (i.e. removing "don't know" responses) from Tag survey woodstove/insert households, 89 were found to have a certification label or tag (although as noted earlier not all could be read by the respondents). The remaining 39 when ZIP code Census-weighted represented a "true" uncertified stove/insert fraction of 32.2%.

As shown earlier in Table 5.6-20, the proxy-based uncertified stove fraction estimates from the Home Heating surveys have been on a steady downward decline (in part based on the fixed installation date cutoff). Thus in order to make an equivalent comparison to the true uncertified fraction from the 2013 Tag survey, this Home Heating proxy trend was extrapolated forward to 2013 using a fitted exponential curve approach illustrated in Figure 5.6-29. The diamond shaped marker points are the proxy-based uncertified stove fractions from Table 5.6-20. (Values for 2008 and 2009 shown as gray markers in were interpolated from the 2007 and 2010 survey fractions.)

Figure 5.6-29
Curve-Fitted Forecast of 2013 Proxy-Based
Home Heating Survey Uncertified Stove/Insert Fraction



A least-squares exponential curve was fitted to these data as shown by the dashed line and used to forecast a proxy-based estimate to 2013, shown as a red marker in Figure 5.6-29. This 2013 forecasted proxy-based uncertified stove fraction was 20.76%.

The difference between the two 2013 estimates (true vs. proxy) of the uncertified stove fraction was 11.47% (32.23% - 20.76%) and was assumed to represent the "offset" that accounted for the underreported uncertified stoves in the Home Heating proxy-based approach. (How this offset was used in the SIP inventory is discussed in the next sub-section.)

The 39 Tag survey responses used to represent the true uncertified stove/insert fraction were also further examined to cross-check the approach used to calculate this proxy offset. 34 of the 39 "true" uncertified device respondents provided installation/age information for their stoves/inserts; 18 (53.4%) were installed on or before 1988; 16 (46.6%) after 1988. The post-1988 split was then multiplied by the true uncertified stove fraction of 32.2% to produce a "proxy-equivalent" estimate of 15.0% (32.2% × 46.6%), which compares reasonably with the 11.47% offset estimated above.

Natural Gas Expansion – Two questions were included in the Tag survey to gauge willingness of existing wood-burning households to switch to using natural gas under a planned expansion of natural gas availability being guided by the Alaska Interior Development Energy Authority (AIDEA).

The first question asked respondents to estimate the retail price gas would need to be offered at to get them to switch from wood (and heating oil). To make the question easier to understand

and the answers more meaningful, the price question was asked on a heating oil equivalent basis: *"If natural gas becomes available, what gas price would get you to stop burning wood (in $/gal equivalent of heating oil)?"* Out of 140 definitive responses, the average gas price was $2.17 per gallon on an oil equivalent basis. 102 of the 140 respondents, or 72.8% indicated willingness to switch to gas if offered at $2.00 gallon equivalent, about half of the current heating oil price.

The second question dealt with the potential need of wood-burning households that switch to gas to continue to burn wood on extremely cold days (less than -30°F) for reasons such as ensuring particular rooms or areas of the house stayed warm. Of the 185 definitive responses to this question, 37.9% (71 respondents) indicated they may still feel the need to use their wood devices on cold days, even after switching their house to natural gas.

Wood Species Mix – Finally, responses were also tabulated from the question asking homeowners to identify the predominant species of firewood they burned. Out of a total of 191 valid responses, the ZIP code Census-weighted composite fractions were as follows:

- Birch (paper birch) – 46.4%;
- Spruce (white spruce) – 34.1%; and
- "Aspen" (black/white poplar) – 18.5%.

Key Purchase Survey Findings – Beside results summarized earlier in conjunction with the Tag survey, a key finding from the Wood Purchase survey was the mix of whole logs (or round) versus pre-split logs purchased. At the time of purchase the 81 responses were split as follows:

- Split – 31 or 38.3%;
- Whole/Rounds – 40 or 49.4%; and
- Both – 11 or 12.3%.

A follow up question was asked of those purchasing whole logs/rounds about when they split their wood, 'as needed' or 'on delivery.' Roughly 44% said 'as needed', the remaining 56% responded 'on delivery.'

Normalizing these tabulation to remove the 'Both' responses and account for splitting by the homeowner after delivery, the mix of split vs. whole/round logs was calculated to be roughly 75% vs. 25%.

Survey Data Use in SIP Inventories

As pointed out in the preceding sections, a variety of telephone-based residential surveys have been conducted in Fairbanks dating as far back as early 2006 in order to ascertain information about local space heating practices, as well as their trends over time. This sub-section clarifies two specific elements of these surveys that were utilized to calculate space heating emissions within the SIP inventories. It also describes how they were applied as inputs in these calculations. Except where explicitly noted, these inputs were based on the 2011 Home Heating survey. It was selected over earlier surveys to represent 2008 baseline inventory heating practices because of its larger sample size and inclusion of cell phone-reached households.

Device Energy Usage Splits by ZIP Code – As discussed earlier, the Home Heating survey data included tabulations of the mix of heating devices in sampled homes and rough estimates of wintertime use percentages provided by the respondent at the beginning of the telephone survey. Later in the device-specific sections of the survey, respondent provided estimates of winter season (and annual) fuel use (e.g., cords of wood or gallons of heating oil) or costs (amount spent per winter month on natural gas or District heat).

A key input to the home heating energy model as discussed earlier under the "Development of Energy Model" section of this appendix was the seasonal average device energy use mix in the household. In the SIP inventory application of the energy model, this winter average household device energy use split was developed and applied from ZIP code-specific tabulations of device energy use splits developed from the 2011 Home Heating survey data. However, instead of using the roughly estimated splits provided by respondents at the beginning of the survey, more robust splits were calculated from the seasonal fuel use data provided later in the survey.

These calculations were performed by converting average seasonal fuel use (for each equipped device in the household) into energy use by multiply by each fuel's specific energy content. Table 5.6-26 lists the energy contents assumed for each fuel and their data sources.

Table 5.6-26
Assumed Energy Contents of Space Heating Fuels in Fairbanks

Fuel	Energy Content	Units	Source/Notes
Wood, dry	13.5	mmBTU/ton	Alaska Department of Natural Resources http://forestry.alaska.gov/pdfs/firewood.pdf, Wood density = 1.56 tons/cord
Heating Oil #1	125,000	BTU/gal	Cold Climate Housing Research Center (energy content for #1 oil in heating appliance survey)
Heating Oil #2	138,500	BTU/gal	North American Combustion Handbook, from http://en.wikipedia.org/wiki/Heating_oil
Fairbanks #1 & #2 Blend	132,000	BTU/gal	Fairbanks Natural Gas, http://www.fngas.com/calculate.html
Kerosene	135,000	BTU/gal	http://generatorjoe.net/html/energy.asp
Natural Gas	1,015	BTU/ft^3	Fairbanks Natural Gas, http://www.fngas.com/calculate.html Gas cost = $2.34 per 100 ft^3
Coal	15.3	mmBTU/ton	http://www.usibelli.com/Coal-data.php
Electric	3,413	BTU/kWh	Fairbanks Natural Gas, http://www.fngas.com/calculate.html Electricity cost = $0.180 per kilowatt-hour (kWh)

Multiplying by these fuel energy contents, average winter season fuel use estimates from the 2011 Home Heating survey were then translated into winter season energy use estimates. These calculations were performed by ZIP code. Average fuel use for each fuel and device type for all households within each ZIP code was converted to average winter season energy use estimates by ZIP code. For device categories such as natural gas and electric heat, fuel cost rather than fuel use data were collected in the survey since it was easier for respondents to provide cost rather than usage data for these categories. Table 5.6-26 lists the unit costs for these fuels that were used to translate the survey data into seasonal fuel use.

The results of these energy use calculations are presented in Table 5.6-27. Actual energy use (winter season BTUs per household) has been translated into normalized percentages in the table. Based on the availability of separate emission factors for specific device/fuel combinations, splits from the survey data were stratified into the categories shown in Table 5.6-27. The energy use estimates for the cell phone households were proportionally distributed into each ZIP code based on their share of the survey sample and 2010 Census weightings.

Table 5.6-27
2011 Home Heating Survey Winter Season Energy Use Splits by ZIP Code

Fuel Group	Device/Fuel Type	Pct. of Winter Season Energy Use by ZIP						Census Wtd. Avg.
		99701	99703	99705	99709	99712	99775	
Wood-Burning	Stoves, cordwood	6.18%	20.32%	17.46%	20.52%	19.63%	11.41%	16.10%
	Stoves, pellet	0.09%	3.05%	0.35%	0.25%	1.20%	0.09%	0.48%
	Inserts, cordwood	1.38%	0.00%	1.96%	0.42%	1.09%	0.00%	1.09%
	Inserts, pellet	0.00%	0.00%	0.98%	0.00%	0.00%	0.00%	0.23%
	Fireplaces	0.49%	0.03%	0.77%	0.99%	0.03%	0.03%	0.65%
	Outdoor Wood Boilers	1.95%	1.15%	7.58%	3.69%	1.58%	1.15%	3.81%
Oil-Burning	Central Oil	78.98%	60.66%	63.64%	65.06%	62.49%	84.42%	67.72%
	Portable Heaters	1.41%	0.83%	1.56%	0.56%	0.85%	0.36%	1.06%
	Direct Vent Heaters	3.19%	3.40%	4.11%	5.92%	10.60%	1.78%	5.24%
Gas	Natural Gas Heat	5.46%	9.99%	1.12%	1.21%	1.71%	0.63%	2.70%
Coal	Coal Heaters	0.58%	0.13%	0.45%	0.30%	0.77%	0.13%	0.45%
Steam	District Heat	0.29%	0.42%	0.01%	1.08%	0.05%	0.01%	0.47%
Totals		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Highlighted rows in Table 5.6-27 refer to those devices for which in-use measurements were collected under the aforementioned CCHRC study, and which were used to construct the home heating energy model. These highlighted energy use percentages were regrouped into the splits listed in Table 5.6-28 for use in driving this portion of the energy model input. As explained later in the “Space Heating - Emission Calculation Details” section, emissions for those devices not represented in the CCHRC study (those not highlighted in Table 5.6-27 and Table 5.6-28) were calculated from their proportional energy use outside the energy model.

Table 5.6-28
Regrouped Winter Season Energy Use Splits by ZIP Code for Energy Model Input

Fuel Group	Device/Fuel Type	Pct. of Winter Season Energy Use by ZIP						Census Wtd. Avg.
		99701	99703	99705	99709	99712	99775	
Wood-Burning	1 – Stoves	7.65%	23.37%	20.75%	21.19%	21.92%	11.50%	17.67%
	2 – Fireplaces	0.49%	0.03%	0.77%	0.99%	0.03%	0.03%	0.62%
	3 – OWBs	1.95%	1.15%	7.58%	3.69%	1.58%	1.15%	4.41%
Oil-Burning	4 - Central Oil	78.98%	60.66%	63.64%	65.06%	62.49%	84.42%	66.20%
	5 - Direct Vent Heat	3.19%	3.40%	4.11%	5.92%	10.60%	1.78%	6.14%
	Portable Heaters	1.41%	0.83%	1.56%	0.56%	0.85%	0.36%	1.24%
Natural Gas	Natural Gas Heat	5.46%	9.99%	1.12%	1.21%	1.71%	0.63%	2.79%
Coal	Coal Heaters	0.58%	0.13%	0.45%	0.30%	0.77%	0.13%	0.52%
Electric	Electric Heat	0.29%	0.42%	0.01%	1.08%	0.05%	0.01%	0.41%
Instrumented Study Subtotals		92.26%	88.62%	96.86%	96.86%	96.62%	98.87%	95.04%
Totals		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Forecasted Trends in Uncertified Stoves/Inserts – As discussed earlier in summarizing the key findings from the 2013 Wood Tag survey, EPA certification data obtained for woodstoves and inserts sampled under that effort enabled development of an offset or correction factor to upwardly revise underreported fractions of uncertified stoves/inserts from the Home Heating surveys.

Table 5.6-29illustrates how this offset was used in conjunction with development of trends in the split between certified and uncertified stoves/inserts over time that were applied in representing their effects in both the baseline (2008) and projected baseline (2015, 2017 and 2019) inventories. The first column in Table 5.6-29 lists the uncorrected fractions of uncertified stoves/inserts tabulated from the annual Home Heating surveys dating back to the inaugural survey in 2006. (As noted earlier, 2008 and 2009 fractions were interpolated from 2007 and 2010 survey results.) The 11.47% correction factor determined from the Tag survey is shown in the next column and was assumed to be a constant offset over time. (In the absence of additional corroboratory data other than that collected in the 2013 Tag survey and given that the law under which uncertified woodstove-like devices has not changed, it was believed that a constant offset adjustment over time was reasonable.)

The remaining columns of Table 5.6-29 show the corrected splits between uncertified and certified (both non-catalytic and catalytic) stoves/inserts from the historical Home Heating surveys after applying the offset adjustment to the uncertified fractions. The shaded cells in the table highlight the corrections to the uncertified fractions over time. For example in 2008, the Home Heating survey-based estimate of 43.05% was increased by 11.47% to yield a corrected estimate of 54.52%. After applying this correction for each historical calendar year, the splits for the remaining certified non-catalytic and catalytic were proportionally renormalized as shown in the next two columns of Table 5.6-29.

Table 5.6-29
Corrected Splits and Trends in Uncertified and Certified Stoves/Inserts

Calendar Year	Home Heating Survey-Based Uncertified Pct.	Tag Survey Offset	Corrected Percentages			
			Uncertified	Certified, Non-Catalytic	Certified, Catalytic	Total
2006	52.01%	+11.47%	63.47%	27.24%	9.29%	100.00%
2007	46.73%		58.20%	31.93%	9.87%	100.00%
2008	43.05%		54.52%	31.94%	13.54%	100.00%
2009	39.37%		50.84%	31.51%	17.66%	100.00%
2010	35.69%		47.16%	30.62%	22.23%	100.00%
2011	25.16%		36.62%	38.29%	25.08%	100.00%
2012	22.76%		34.23%	41.22%	24.56%	100.00%
2013			*32.23%*	*42.47%*	*25.30%*	*100.00%*
2014			*29.52%*	*44.16%*	*26.31%*	*100.00%*
2015			*27.17%*	*45.64%*	*27.19%*	*100.00%*
2016			*25.13%*	*46.92%*	*27.95%*	*100.00%*
2017			*23.35%*	*48.03%*	*28.62%*	*100.00%*
2018			*21.80%*	*49.00%*	*29.19%*	*100.00%*
2019			*20.46%*	*49.85%*	*29.70%*	*100.00%*

As shown in the *italicized* lower section of Table 5.6-29, estimates of uncertified stove/insert fractions over time out to 2019 (the latest inventory projection year) were forecasted to continue their natural downward trend observed from 2006 through 2012 survey data using the exponential curve and equation presented earlier in Figure 5.6-29 and the constant 11.47% additive adjustment. The corrected splits and trends in Table 5.6-29 were applied to represent stove/insert uncertified/certified fractions in the baseline and projected baseline SIP inventories.

Home Heating – Fairbanks Wood Energy and Moisture Effects

For biofuels such as wood, the moisture level has a significant effect on the net heating energy when the fuel is burned as well as on resulting emission factors (mass emissions of pollutant per unit mass of fuel). Energy content of the locally-available firewood species must also be accounted for. This section of the Emission Inventory Technical Appendix describes how Fairbanks-specific wood energy and moisture effects were accounted for within the Residential Space Heating sector of the SIP inventories.

The section begins by summarizing the sources and methods used to estimate the energy content of Fairbanks-specific wood used in home heating. It also contains a discussion of basic concepts in representing and accounting for heating energy effects of wood as a function of its moisture content. Next, the data and sources used to estimate baseline moisture levels across the spectrum of Fairbanks wood burners are described. The final sub-section documents how these elements were combined to calculate effects of moisture content on wood-burning emissions within the SIP inventories.

Fairbanks Wood Energy Content

The energy content per unit volume of firewood varies by over a factor of two[20], depending on the species of the wood. Although energy content per unit mass shows much less variation across wood species, firewood is cut, purchased and stacked/stored on a volumetric basis (e.g., in cords) and therefore understanding the types/mix of Fairbanks firewood species is important.

Common woods in the conterminous U.S. typically exhibit an average energy content of roughly 8,500 BTU/lb on an oven dry (i.e. bone dry) basis. In EPA's AP-42 emission factor database, residential wood burning emission factors are based on an energy content of 17.3 mmBTU/ton[21] (equal to 8,650 BTU/lb).

(As discussed in the detail in following sub-section, wood moisture also has a significant effect on its effective energy content or heating value. Therefore wood energy content is generally reported on a fully-dried basis, or at a reference moisture level. This sub-section deals solely with energy content variations by wood species, irrespective of moisture level.)

To better represent the energy content of firewood burned for space heating in Fairbanks, information on the relative usage of local wood species used in residential heating was collected from a 2013 "Wood Tag" survey of 216 randomly-selected wood-burning households located within the Fairbanks NAA. The three predominant local firewood species are: 1) Birch; 2) White Spruce; and 3) Aspen. Local firewood called "Aspen" is actually a mix of white poplar (American Aspen) and black poplar (Cottonwood) species that grow in the area.

[20] "Firewood BTU Content Charts," Chimney Sweep Online, http://www.chimneysweeponline.com/howood.htm.
[21] http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s10.pdf

Table 5.6-30 lists the relative usage fractions for each of the three primary local wood species (Birch, Spruce and Aspen) tabulated from the 2013 Wood Tag survey responses. It shows that Birch and Spruce are the most commonly used firewood species.

Table 5.6-30
Fairbanks Firewood Usage Splits and Energy Content by Species

Parameter	Local Wood Species			Composite
	Birch	Spruce	Aspen	
Usage Fraction	46.4%	35.1%	18.5%	100%
Energy Content (BTU/lb)[a]	8,126	8,518	8,252	**8,119**

[a] Assuming 0% moisture or oven dry basis.

Table 5.6-30 also shows energy contents assumed for each specie (on an oven dry basis), based on Alaska-specific data[22] published by the Alaska Department of Natural Resources (ADNR). The energy contents shown in Table 5.6-30 are adjusted to an oven-dry basis from the ADNR values, which reflect 20% moisture content, or "air dry" conditions. As highlighted in the rightmost column of Table 5.6-30, the composite energy content of Fairbanks firewood (weighted by the specie-specific usage percentages) was estimated to be 8,119 BTU/lb on an oven dry (OD) basis.

Wood Moisture and Energy Relationship

When harvested, wood has a certain amount of water or moisture suspended within its mass. The amount of moisture in wood is referred to as its moisture content (MC). Wood moisture content is generally defined on a percentage basis relative to either:

1. the mass of the wood including its water (wet basis, wb); or
2. the mass of the wood excluding the water (dry basis, db).

Wood moisture levels are rigorously measured in the laboratory by measuring the mass of wood before and after placing it in a drying oven (where all its suspended water is evaporated). For example, if a piece of wood had a wet mass (before drying) of 1.25 lb and a dry mass of 1.00 lb, its moisture content on both a wet or dry basis would be calculated as follows:

$$MC\ Wet\ (MC\ wb) = (Mass_{Wet} - Mass_{Dry}) \div Mass_{Wet} = (1.25 - 1.00) \div 1.25 = 0.20 \text{ or } 20\%$$
$$MC\ Dry\ (MC\ db) = (Mass_{Wet} - Mass_{Dry}) \div Mass_{Dry} = (1.25 - 1.00) \div 1.00 = 0.25 \text{ or } 25\%$$

Moisture levels also affect how wood energy content is reported, depending on what state the wood's suspended water molecules are in after being vaporized during combustion. Gross or

[22] "Purchasing Firewood in Alaska," Alaska Department of Natural Resources, Division of Forestry, http://forestry.alaska.gov/pdfs/firewood.pdf.

Higher Heating Value (HHV) energy content includes energy associated with the latent heat of vaporization of moisture within the wood when condensed after combustion. Net or Lower Heating Value (LHV) energy content excludes this latent heat of vaporization. Under bone dry conditions, both heating values are the same. At moisture levels other than 0%, LHV energy content is lower than that based on the HHV. The equations below, excerpted from the U.S. Department of Energy Biomass Energy Data Book[23] and converted to English units, show how wood HHV and LHV vary by wood moisture content.

$$\boldsymbol{HHV = HHV_{dry} \times (1 - MC_{wb})} \quad \textbf{(4)}$$

$$\boldsymbol{LHV = HHV_{dry} \times (1 - MC_{wb}) - 1050\, MC_{wb}} \quad \textbf{(5)}$$

Where:

HHV = higher heating value (BTU/lb) which includes latent heat of vaporization;
LHV = lower heating value (BTU/lb) which excludes latent heat of vaporization;
HHV_{dry} = laboratory-measured energy content or bone dry HHV (BTU/lb);
MC_{wb} = wood moisture content (%, wet basis); and
1050 = a constant that represents the latent heat of vaporization (at 25°C).

Table 5.6-31 presents calculated Fairbanks wood energy content (on both an HHV and LVH basis) as a function of various moisture levels, expressed on both a wet and dry basis.

Table 5.6-31
Fairbanks Wood Energy Content (BTU/lb) vs. Moisture Content (%)

MC Wet (%)	MC Dry (%)	HHV (BTU/lb)	LHV (BTU/lb)	%HHV Reduction Relative to Oven Dry
0.0%	0.0%	8,119[a]	8,119[a]	0%
5.0%	5.3%	7,713	7,661	5.0%
10.0%	11.1%	7,307	7,202	10.0%
15.0%	17.6%	6,902	6,744	15.0%
20.0%	25.0%	6,496	6,285	20.0%
25.0%	33.3%	6,090	5,827	25.0%
30.0%	42.9%	5,684	5,369	30.0%
35.0%	53.8%	5,278	4,910	35.0%
40.0%	66.7%	4,872	4,452	40.0%
45.0%	81.8%	4,466	3,993	45.0%
50.0%	100.0%	4,060	3,535	50.0%

[a] Based on composite bone dry energy content for local firewood mix.

[23] B. Boundy, et al., "Biomass Energy Data Book: Edition 4," Oak Ridge National Laboratory, Report No. ORNL/TM-2011/446, September 2011.

The specific value to use depends on the combustion device and application. Wood burning devices used in residential space heating cannot recover latent heat energy from water vapor produced during combustion. Therefore their heating value or efficiency in the real world would be based on the LHV. This approach is used in Europe. In the U.S. however, residential wood device heating value specifications and efficiencies have traditionally been published on an HHV basis, including data reported through EPA's woodstove certification standards. In order to be consistent with U.S. published data and efficiency ratings (used later in emission inventory and control measure calculations), HHVs were used to account for moisture effects in residential wood burning.

Wood Moisture and Emissions – The energy content vs wood moisture relationship shown in Table 5.6-31 results in a commensurate or proportional impact on wood-burning emissions. Relative to any "reference" moisture level, the amount of additional wood that must be burned is directly related to the difference in energy content between the actual and reference moisture levels. The relative reduction in HHV-based energy content at any moisture level relative to 0% (Oven Dry) moisture content is shown in the highlighted column in Table 5.6-31. The reduction in relative HHV is mathematically equal to the wet-basis moisture content.

Beyond this proportional HHV vs. moisture content impact, emissions from wood-burning devices are also affected by factors that reduce optimum combustion conditions. Wood burning devices are tested for emissions and efficiency performance with "air dry" wood in a moisture content range of about 18% to 28% (15% to 22% wet basis) to represents the normal range most people use or should use. Both higher and lower moisture content can have significant negative consequences[24]. High moisture reduces efficiency and makes it harder to start and sustain good secondary combustion. This is due to its cooling effect that slows down combustion and cools the gases produced by pyrolysis. Very dry wood tends to burn faster and can evolve gases at a rate that outstrips the ability of most heating devices to supply adequate air, resulting in oxygen starvation. This can cause higher emissions, pulsating combustion and overheating.

Available literature that quantifies these moisture-driven combustion effects on resulting device emission levels is extremely limited. In a comparative analysis[25] of wood device testing results from both laboratory measurements and in-home instrumented studies, Houck (2012) observed that any clear relationship that wood moisture alone might have with emissions is clearly obscured by other real-world variables. Earlier studies[26,27] also note the difficulty in isolating the moisture-combustion effect on emission rates in historical test measurements and suggest its magnitude is smaller compared to other sources of variation in the data.

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[24] R. Curkeet, "Wood Combustion Basics," Intertek Worldwide, EPA workshop presentation, March 2, 2011, http://www.epa.gov/burnwise/workshop2011/WoodCombustion-Curkeet.pdf

[25] J. Houck, "A Comparison of Particulate Emission Rates from the In-Home Use of Certified Wood Stove Models with U.S. EPA Certification Emission Values and A Comparison between In-Home Uncertified and Certified Wood Stove Particulate Emissions," prepared for Hearth, Patio & Barbecue Association, February 1, 2012. Docket EPA-HQ-OAR-2009-0734.

[26] R. Curkeet and R. Ferguson, "EPA Wood Heater Test Method Variability Study," prepared for Hearth, Patio and Barbecue Association, October 6, 2010.

[27] J. Houck and P. Tiegs, "Residential Wood Combustion Technology Review Volume 1. Technical Report," prepared for U.S. Environmental Protection Agency, Report No. EPA-600/R-98-174a, December 1998.

Although the observed literature acknowledges a moisture-combustion effect on device emission rates, a statistically significant relationship isolating this effect does not appear to have been developed. Therefore, wood-burning emissions in the SIP inventories are based solely on the moisture-energy content effect described earlier.

BASELINE MOISTURE LEVELS

Having developed estimates of local firewood species and their energy content and identifying effects of wood moisture content on effective energy content (or HHV), the next step consisted of assembling baseline wood moisture levels for firewood burned in Fairbanks during winter. Two primary data sources were used:

1. Usage splits developed from Fairbanks home heating surveys on fractions of households that purchase wood sold commercially vs. those that cut their own wood (Cut group);

2. Wood moisture measured from the wood-burning homes in the aforementioned CCHRC Home Instrumentation study (used to the develop the space heating energy model; and

3. Moisture measured in experimental wood piles under a second CCHRC study[28].

Wood Source Groups - In each of the residential home heating surveys, residents were asked to identify the source of wood used in their home categorized as follows:

- Buy - those that they purchased commercially;
- Cut – those that cut their own wood; and
- Both – those using a mixture of wood they cut themselves and purchased commercially.

Table 5.6-32 shows the “Wood Source” results tabulated from the home heating surveys. Results shown for the 2008 inventory baseline were interpolated from wood source data collected in the 2007 and 2010 Home Heating surveys. Data for calendar year 2013 were developed from the “Wood Tag” survey. (This survey targeted wood-burning households and had roughly twice the sample of wood burning respondents than in each home heating survey).

Since the fraction of Buy vs. Cut wood sources in households that responded “Both” was not known from the surveys, this response was not used. As highlighted at the bottom of Table 5.6-32, the fractions of Buy and Cut wood source groups from each historical survey were then renormalized.

Once the household fractions within each wood source group were tabulated, separate data sources were used to estimate average wood moisture levels within each group. This distinction was made to account for the fact that homeowners who cut their own wood tend to be those that have built storage sheds with ample capacity and season or dry their wood for longer periods than those purchasing wood commercially.

[28] “Wood Storage Best Practices in Fairbanks, Alaska,” prepared by Cold Climate Housing Research Center, June 27, 2011.

Table 5.6-32 Fairbanks Residential Survey Wood Source Fractions				
Wood Source Group	2008 Interp. HH Survey	2011 HH Survey	2012 HH Survey	2013 Tag Survey
Buy Wood	30.8%	26.7%	36.2%	22.4%
Cut Own	57.1%	62.1%	49.0%	63.1%
Both (Buy & Cut)	12.1%	11.1%	14.8%	14.5%
Total	100.0%	100.0%	100.0%	100.0%
Normalized, Buy	**35.0%**	**30.1%**	**42.5%**	**26.2%**
Normalized, Cut	**65.0%**	**69.9%**	**57.5%**	**73.8%**

Cut Group Moisture – As noted earlier, homeowners who cut their own wood (rather than buying it commercially) tend to be those who pre-plan and generally have constructed wood storage sheds or areas on their property. During the CCHRC Home Instrumentation study, it was observed that a number of the wood-burning participants in that study (the Mixed and Wood households) appeared to fit this profile of homeowners that cut their wood and had on-site storage for it. The moisture content of the wood stacks from each of these Mixed and Wood households in the Instrumented study was measured at the time of the instrumentation (Dec 2010-Feb 2011).

In the absence of any additional detailed data, it was assumed that the average wood moisture content from these 20 households provided a reasonable estimate of the wood moisture for homeowners in the Cut group. Table 5.6-33 lists the measured moisture content (dry basis) from the wood samples taken from each of these households. Moisture levels ranged from a low of 17% to a high of 58%, with an average of 26.6% shown at the bottom of Table 5.6-33.

Half of the measured moisture levels were in the “air dry” range (from 17% to 21%). This is consistent with anecdotal evidence noted earlier that homeowners who cut their own wood tend to properly store their wood and allow for a drying period of at least several months. And since the moisture measurements were taken during mid-winter, they are representative of winter season modeling episodes.

Thus the average moisture content from this sample of 26.6% was assumed to reasonably approximate wood moisture for the Cut group of households.

Table 5.6-33 Estimated Cut Group Moisture Content Based on CCHRC Instrumentation Study Wood Samples	
CCHRC Household ID	Moisture Content (%, db)
1	25%
2	18%
3	17%
4	27%
5	20%
6	18%
7	33%
8	18%
9	38%
10	20%
21	21%
22	31%
23	24%
24	24%
25	19%
26	32%
27	58%
28	20%
29	21%
30	48%
Sample Average	**26.6%**

Buy Group Moisture – Wood moisture content for the Buy group of wood-burning households was developed from CCHR's "Wood Storage Practices" study. This study consisted of experimental development and testing of moisture content different types (wood species) and storage/covering practices. Wood was cut and stored at two different points during the year:

1) *Spring Harvest* – wood cut in late May, simulating those homeowners that plan ahead and allow wood to dry over summer; and

2) *Fall Harvest* – wood cut in mid-September, simulating those that wait until fall to cut wood for immediate use in winter.

After each harvest, the wood was stored in different configurations that included a simulated wood shed and tarp covered, and uncovered stacks. Both whole log and split log stacks were prepared. Moisture measurements were then taken from randomly-selected logs within each stack at different durations after each initial harvest at roughly two month intervals, from immediately after stacking to up to 12 months later.

Table 5.6-34 lists the moisture levels (dry basis) measured by CCHRC for the Spring and Fall harvest cuts by storage method, wood type and seasoning period (in months from cut shown in green shaded cells above the month each moisture measurement was conducted.).

Table 5.6-34
Moisture Content Measurements from CCHRC Wood Storage Practices Study

Spring Harvest Moisture Content by Sampling Month (%, db)							
	Seasoning Months →	0	1.5	3	8	10	12
Storage Method	Wood and Log Type	Late May	July	Late Aug	Jan	March	May
Simulated Wood Shed	Birch – split	52%	20%	18%	**15%**	**15%**	**15%**
Simulated Wood Shed	Birch – whole)	52%	30%	25%	29%	28%	24%
Simulated Wood Shed	Spruce – split	86%	16%	17%	**15%**	**15%**	**15%**
Simulated Wood Shed	Spruce – whole	86%	28%	21%	23%	24%	17%
Simulated Wood Shed	Aspen – split	76%	26%	20%	**15%**	**15%**	**15%**
Simulated Wood Shed	Aspen – whole	76%	49%	44%	40%	*33%*	26%
Tarp Covered	Birch – split	49%	21%	20%	**15%**	**15%**	**15%**
Tarp Covered	Birch – whole	49%	28%	31%	32%	*29%*	25%
Tarp Covered	Spruce – split	86%	22%	22%	35%	*27%*	18%
Tarp Covered	Spruce – whole	86%	67%	30%	29%	*26%*	23%
Uncovered	Birch – split	57%	19%	35%	46%	38%	17%
Uncovered	Birch – whole	57%	29%	32%	52%	39%	25%
Uncovered	Spruce – split	77%	17%	19%	**15%**	**15%**	**15%**
Uncovered	Spruce – whole	77%	29%	27%	47%	29%	17%
Solar Kiln	Aspen – split	59%	24%	16%	**15%**	**15%**	**15%**
Solar Kiln	Aspen – whole	59%	38%	32%	34%	31%	27%

Fall Harvest Moisture Content by Sampling Month (%, db)					
	Seasoning Months →	0	4	6	8
Storage Method	Wood and Log Type	Mid Sept	Jan	March	May
Simulated Wood Shed	Birch – split	80%	49%	42%	30%
Simulated Wood Shed	Birch – whole)	80%	55%	56%	47%
Simulated Wood Shed	Spruce – split	85%	63%	40%	37%
Simulated Wood Shed	Spruce – whole	85%	77%	72%	51%
Simulated Wood Shed	Aspen – split	83%	63%	51%	34%
Simulated Wood Shed	Aspen – whole	83%	65%	*57%*	48%
Tarp Covered	Birch – split	78%	63%	70%	49%
Tarp Covered	Birch – whole	78%	67%	*62%*	57%
Tarp Covered	Spruce – split	92%	117%	*101%*	84%
Tarp Covered	Spruce – whole	92%	80%	*85%*	89%

Boldface yellow shaded cells in Table 5.6-34 were originally marked as “Dry” by CCHRC. A moisture level of 15% was assumed for these measurements. *Italicized* tan shaded cells denote moisture levels interpolated from adjacent measurements that we missing in the original data.

These data were used to develop separate estimates of Cut group wood moisture for the January-February and November modeling episodes within the SIP inventories by using measured moisture levels from each harvest in these months. Before doing so, it was necessary to estimate splits in wood use by harvest, log type and storage method.

In consultation with ADEC, it was assumed that 25% of wood sold commercially was cut in spring, with the remaining 75% harvested during fall. Greater weight was given to the fall cut due to the short and yearly varying length of the spring wood cutting window, which is affected by the timing of the spring thaw and breakup. Summer months exhibit wet, boggy conditions that can be worsened by thunderstorms, which makes wood harvesting difficult. Early fall is generally when most wood cutting and harvesting occurs, and when commercial wood sellers have a better idea of firewood demand for the upcoming winter months.

Next, the fraction of whole versus split logs was assumed to be evenly divided: 50% whole and 50% split. Not that these are fractions that reflect the state of the logs over duration they are stored in a stack, not the state of logs when burned. (Data collected later under the 2013 Wood Purchase survey roughly corroborate this assumption. The resulting composite moisture level is not strongly sensitive to the mix between whole and split logs based on the CCHRC measurements listed in Table 5.6-34.)

In addition, to represent a composite estimate of storage method-driven difference in moisture content, the “Tarp Covered” values in Table 5.6-34 were used and assumed to represent a mid-range wood storage method in terms of its effectiveness in reducing moisture during seasoning. (For Aspen, moisture levels were based on the “Simulated Wood Shed” measurements since Tarp Covered data were not available for that wood species.)

Given these weighting/selection assumptions, Table 5.6-35 presents average moisture levels by specie (birch, spruce, aspen) for January-February and November, with composites calculated across harvest, log type and storage method. For example, the moisture content for birch during the January-February period was calculated as follows:

$$
\begin{aligned}
MC_{birch,Jan} &= 25\% \times (50\% \times MC_{spring,birch,Tarp,Jan,split} + 50\% \times MC_{spring,birch,Tarp,Jan,whole}) + \\
&\quad 75\% \times (50\% \times MC_{fall,birch,Tarp,Jan,split} + 50\% \times MC_{fall,birch,Tarp,Jan,whole}) \\
&= 0.25 \times (0.50 \times 15\% + 0.50 \times 32\%) + 0.75 \times (0.50 \times 63\% + 0.50 \times 67\%) \\
&= 54.6\%
\end{aligned}
$$

The highlighted column in Table 5.6-35 shows the weighted average moisture content for Buy group wood across all three wood species for each modeling episode. These averages were calculated using the relative usage factors for each species (listed earlier in Table 5.6-30) of 46.4%, 35.1% and 18.5% for birch, spruce and aspen, respectively.

Table 5.6-35
Average Buy Group Moisture Content by Wood Species and Modeling Episode

Episode	Measurement Month(s)	Moisture Content by Species (%, db)			Wtd. Avg. MC (%, db)
		Birch	Spruce	Aspen	
Jan-Feb	Jan	54.6%	81.9%	54.9%	64.2%
Nov	Interpolation from Aug/Sep and Jan	59.8%	78.7%	62.6%	66.9%

Calculation of Moisture Effects

Once Fairbanks wood-specific energy content and moisture content estimates were developed for each type of wood source (Buy vs. Cut), wood moisture effects were calculated by combining elements from the preceding sub-sections to produce composite estimates for both the 2008 Baseline and projected baselines. These calculations are described separately below.

2008 Baseline – The normalized 2008 Buy vs. Cut wood fractions shown earlier in Table 5.6-32 (35% and 65%, respectively) were used to represent wood source splits during 2008. (As noted earlier, these 2008 splits were interpolated from results tabulated from 2007 and 2010 Home Heating surveys). These wood source splits were combined with separate moisture levels estimated for each source group (Buy vs. Cut), to generate weighted composite moisture level across both source groups as shown below in Table 5.6-36. As seen in Table 5.6-36, the composite wood moisture contents (db) for the 2008 Baseline were 39.8% and 40.7% for the January-February and November episodes, respectively. The nominally higher moisture content in November compared to January-February is due to the fact that wet wood cut earlier in the year has less time to season and dry by November compared to the following January-February.

Table 5.6-36
Calculation of 2008 Baseline Wood Moisture Effects

Source Group	Usage Fraction (%)	Moisture Content (%, db) by Modeling Episode	
		Jan-Feb	Nov
Buy	35.0%	64.2%	66.9%
Cut	65.0%	26.6%	26.6%
Composite	**100%**	**39.8%**	**40.7%**
Energy Content (EC)			
HHV (BTU/lb)		**5,928**	**5,889**
EC Relative to Energy Model (26.6%, db)		**0.906**	**0.900**

The last two rows in Table 5.6-36 show the resulting moisture-affected energy content (as HHV in BTU/lb) and the energy content (EC) relative to the reference EC on which the earlier residential heating energy model is based. The moisture level-specific HHVs were calculated using the energy content vs. moisture relationship shown earlier in Equation (4) and Table 5.6-31. (As explained earlier, the energy model's reference EC is the same as that of the Cut group since that was how the Cut group moisture level was estimated.) These relative ECs highlighted in the bottom row of Table 5.6-36 were applied to the BTU estimates generated by the energy model to adjust effective heating energy to reflect composite wood moisture levels within each episode for 2008 Baseline conditions.

2015 and 2019 Projected Baselines – As shown earlier in Table 5.6-32, there appears to be a general trend toward higher fractions of wood use in the Cut group versus the Buy group, despite some year-to-year oscillation. This was confirmed by results tabulated from a parallel effort to the 2013 Wood Tag survey called the Wood Purchase survey in which a separate set of over 200 residential wood-burning households were polled about their wood purchase or self-cutting practices. The wood source splits tabulated from the 2013 Wood Purchase survey of 25.6% Buy and 74.4% Cut were very similar to those from the Wood Tag survey of 26.2% and 73.8% as shown earlier in the rightmost column of Table 5.6-32. This shift toward greater use of self-cut wood appears reasonable as heating oil prices have drifted upward in recent years and residents become more committed to and plan for use of wood as a secondary heat source.

As a result, it was assumed that this shift toward a higher fraction of self-cut wood could be applied in 2013 and later calendar years and was thus used to represent Buy vs. Cut splits for the 2015 and 2019 projected baseline inventories. Table 5.6-37 below is similar to that presented for the 2008 Baseline and shows the resulting effects of this shift to more cut wood in representing wood moisture levels and energy content effects assumed for the 2015 and 2019 projected baselines.

Table 5.6-37
Calculation of 2015 and 2019 Projected Baseline Wood Moisture Effects

Source Group	Usage Fraction (%)	Moisture Content (%, db) by Modeling Episode	
		Jan-Feb	Nov
Buy	26.2%	64.2%	66.9%
Cut	73.8%	26.6%	26.6%
Composite	**100%**	**36.5%**	**37.2%**
Energy Content (EC)			
HHV (BTU/lb)		**6,072**	**6,041**
EC Relative to Energy Model (26.6%, db)		**0.928**	**0.923**

As shown in Table 5.6-37, projected baseline moisture contents (db) of 36.5% and 37.2% for the January-February and November episodes, respectively are nominally lower than those for the 2008 Baseline. These lower levels are driven by the higher Cut group fraction of drier wood that that of the Buy group, highlighted in yellow in Table 5.6-37. They result in commensurate nominal increases in energy content relative to the 2008 baseline as shown at the bottom of Table 5.6-37.

Home Heating – OMNI and AP-42 Emission Factors

In support of more robust SIP emission estimates, the Borough and ADEC have sponsored several local measurement studies designed to better quantify $PM_{2.5}$ and related emissions in Fairbanks in the winter. A key element of this coordinated effort was the FNSB-sponsored study[29] of emission factors from residential space heating appliances and fuels, which was conducted in 2011 by OMNI-Test Laboratories, Inc. (OMNI).

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 emissions and gaseous emission precursors of PM (SO_2, NO_x, VOC and 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 the Research Triangle Institute using XRF, ion chromatography, and thermal/optical analysis.

This section focuses on how Alaska-specific emissions data from the OMNI study data were used to complement EPA's more generic AP-42 Compilation of Emission Factors database for space heating sources. As described in detail in the following sub-sections, the overall approach consisted of using the Fairbanks-specific OMNI emission factor data, where available and reasonable. Where OMNI measurement data were not available, AP-42 emission factors were used.

Emission Factors for Wood-Burning Devices

The main focus of the OMNI study was wood burning appliances and fuels because of their apparent significant contribution to $PM_{2.5}$ in the Fairbanks nonattainment area. Specific wood burning space heaters were selected for testing by OMNI either because they represented popular conventional models in interior Alaska or more advanced models, such as newer EPA-certified wood stoves and EPA-qualified phase 2 Outdoor Wood Hydronic Heaters (OWHHs), that are expected to be representative of future trends. Additionally, one pellet heater was tested. In all, 20 of OMNI's 35 tests were conducted on wood-fired units.

OMNI's wood burning tests used fuel loadings and test protocols generally as prescribed by EPA Method 28 and related EPA sampling methods. However, to provide the most realistic representation of Alaskan wood burning, split cordwood was used, rather than "crib wood" (i.e., dimensional lumber) as prescribed in the test method. In addition, OMNI used White Spruce and Paper Birch (with bark), the two most common cordwood fuels in Fairbanks, rather than the Douglas Fir prescribed in the test method. Locally produced Alaska wood pellets were used for the pellet heater.

[29] "Measurement of Space Heating Emissions," OMNI-Test Laboratories, Inc., May 23, 2013.

OMNI's emission factor results are expressed in various forms, including emissions per kg of dry wood (similar to AP-42 emissions factors). However, testing was performed using representative Fairbanks fuel samples with as-received moisture levels. More specifically, the cordwood and other solid fuels tested by OMNI were collected in Fairbanks under typical fuel storage conditions and preserved to maintain moisture levels prior to their use in testing. In addition, solid fuels were tested for moisture content by OMNI immediately prior to each test.

EPA test procedures were used as the basis for OMNI's emission testing, with adaptations as needed to improve the representativeness of testing or its practicality. (OMNI's study report provides more details.) EPA Method 28 was followed for solid fuel loadings and test duration. However, Method 28 specifies four different firing rates for each device, in effect requiring four different tests for each appliance/fuel combination and then weighting the results to obtain both annual and heating season average emission values. Unfortunately, this ideal approach of conducting four tests for each appliance/fuel combination was not affordable for Fairbanks due to the size of Alaska's required appliance/fuel test matrix.

The solution for Fairbanks was to conduct Method 28 testing for each appliance/fuel at either "low" firing rate or "low" and "max" firing rates only. The "low" firing rate was defined to be a nominal rate of 35% of maximum load. This load was selected by FNSB for two reasons. First, it is very close to and only slightly above the heating season average weighted load for a Method 28 test, which is 34%. Second, it is very close to, and only slightly below, the center of the range for the most frequent (i.e., most heavily weighted) mode of the Method 28 test, which is Category 3. (This Category has a firing rate of 25–50% of maximum, and it is weighted at 0.450 for the heating season average, i.e. it accounts for nearly half of the firing during the heating season.) By also including a maximum firing rate where practical (corresponding to Category 4 of Method 28), the Borough attempted to capture both the average (g/kg) emission factor (primarily for emission inventory purposes) and the maximum or near maximum (g/hr) emission rate for other evaluation purposes (e.g. estimation of near-field impacts from individual sources).

OMNI's study included limited testing to characterize the effect of cold starts, but to date the results of those tests have not been sufficient to quantify the cold start effect. (Because the data were limited, only an indirect estimate could be made of cold start using results from several runs. These data suggest cold starts may add up to 15% to the total $PM_{2.5}$ emissions, but additional testing with a more direct sampling method would be required to confirm this result.) Therefore, Alaska's wood burning and other space heating emission factors, like AP-42 factors, do not include a cold start effect. Recent survey data from Fairbanks suggest that ignoring this effect may be less serious in Fairbanks than locations outside of Alaska because the vast majority of Fairbanks households that burn wood are more than occasional burners (in a 2012 survey, only 9% of wood burners described their usage as "occasional"); rather, they tend to burn out of economic necessity and very regularly, essentially every day in most cases. In addition, as with cold start test attempts, OMNI performed limited testing to characterize the effectiveness of a solid fuel stove catalytic retrofit device, but those test results too were inconclusive.

<u>Comparison of OMNI and AP-42 Representativeness</u> - In contrast to the appliances and fuels selected for their representativeness of Fairbanks in winter and used in the OMNI study, the emissions studies of residential wood burning that underlie EPA's AP-42 average emission

factors include, by design, a broad spectrum of devices, fuels, and conditions. Among the variables reflected in the more than 150 studies relied upon by AP-42 are appliance types, models, ages, and technologies; fuel types (including many wood, coal, and oil types that are either uncommon or not used at all in Fairbanks); fuel conditions (e.g., moisture content), and form factors (crib vs. cordwood); these reflect test methods and field test conditions that are used throughout North America under a much wider variety of circumstances (not all of which are necessarily appropriate for Alaska). These and other features of the OMNI and AP-42 testing are summarized in Table 5.6-38.

An element not directly compared in Table 5.6-38 is measurement of particle size in reporting PM emission test results. While not correct, total PM, PM_{10}, and $PM_{2.5}$ are often used interchangeably. As noted by Houck[30] (2008), AP-42 states "PM-10 is defined as equivalent to total catch by EPA method 5H train." Most inventories treat the AP-42 values as either PM_{10} or $PM_{2.5}$ and essentially equivalent to each other. Research into the size distribution of particles from a certified catalytic model showed that PM_{10} averaged about 88% of the total particulate catch and $PM_{2.5}$ averaged about 80%; similar research with a certified non-catalytic model showed that PM_{10} averaged about 94% and $PM_{2.5}$ about 92% of the total catch.[31] OMNI's reported test results are size-segregated $PM_{2.5}$ measurements. As noted above, AP-42 published rates do not distinguish particle size.

As a compendium of generic emission factors, AP-42 is both relatively large in scope and a reliable information resource. However, there are several and serious technical challenges to applying the AP-42 average emission factors to Fairbanks wood burning. One of the first problems is lack of geographic specificity. AP-42 does not specify the exact mix of wood types that were used for its testing, but it is known from reviews of AP-42 that they are not dominated by either Paper Birch or White Spruce, the two most common types in Fairbanks. Furthermore, the current woodstove population and technology in Fairbanks and represented in the OMNI study is almost certainly newer than the AP-42 database. This is true not only because the AP-42 database tends to be much older, but also because wood burning in Fairbanks has increased sharply in recent years due to escalating heating oil prices and some of the nation's highest home heating costs (average about $3,700/year). This means (and recent ADEC-sponsored telephone surveys tend to support) that the Fairbanks wood burning device population has not only a higher fraction of certified wood burning devices, but also more of the newest (and lowest-emitting) of the certified devices. Finally, while many of the AP-42 wood appliance tests were reportedly conducted under "field conditions," presumably using representative wood moisture levels for those locations and seasons, we do not know whether the fuel moistures and firing rates in those tests were representative of Fairbanks in winter. In the case of OMNI's testing, OMNI and the Borough took steps to ensure the representativeness of Fairbanks fuel samples and the preservation of sample moisture prior to testing. In addition, OMNI measured and reported the fuel moisture levels (except for liquid fuels) before each test, and they used appropriate heating season average (and selected maximum) firing rates.

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[30] J.E. Houck, et al., "Emission Factors for New Certified Residential Wood Heaters," presented at EPA's 17th Annual International Emissions Inventory Conference, June 2008, http://www.epa.gov/ttnchie1/conference/ei17/session4/houck.pdf.

[31] McCrillis, R.C., Wood Stove Emissions: Particle Size and Chemical Composition, U.S. Environmental Protection Agency, Research Triangle Park, NC, 2000, EPA-600/R-00-050.

Table 5.6-38
Comparison of OMNI Heating Device Testing and AP-42 Emission Factors

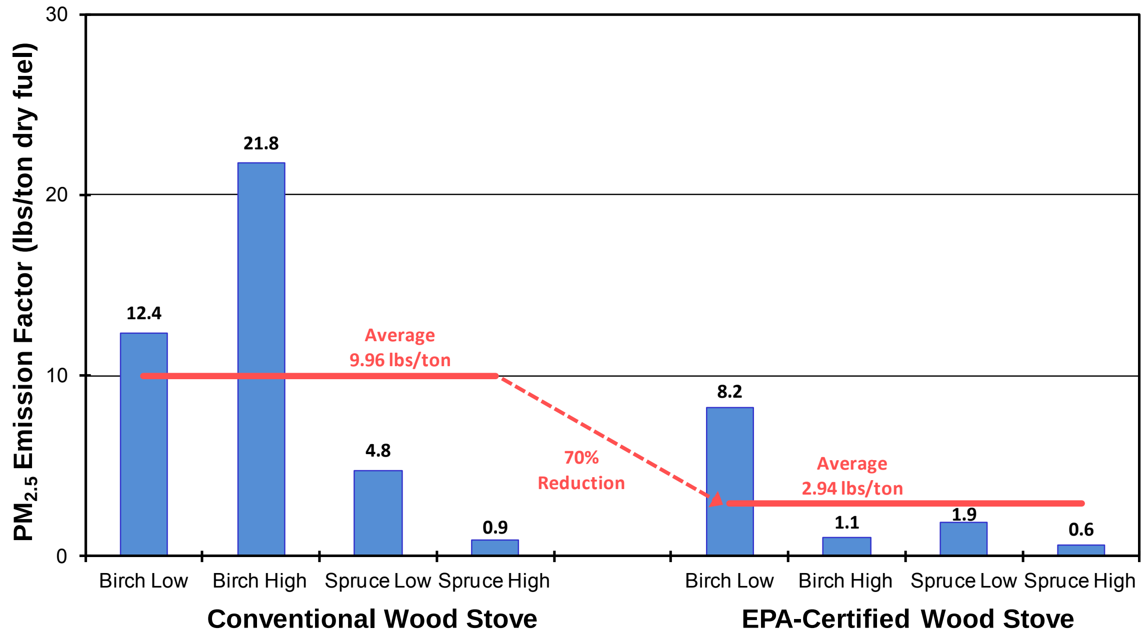
Features	OMNI Test Program	AP-42
Geographic Representation	Testing specific to interior Alaska appliances/fuels/winter conditions;	Testing designed to be representative of average emissions nationwide
Currency	2011 test program, supported by concurrent usage and measurement data (fuel type & moisture, in-use stack temperature monitoring, etc.)	Pertinent sections of AP-42 date from October 1996 or earlier; references dated 1972-2001
Appliances	"Conventional" and "advanced" wood stoves and outdoor hydronic heaters; pellet stove; coal stove; auger-fed coal OHH; fuel and waste oil burners (total: 9 appliances)	Large number and variety of appliances
Sample Size	35 tests conducted	More than 150 studies; hundreds of tests
Fuel Selection	Paper Birch & White Spruce (most common Fairbanks woods); locally produced wood pellets; Usibelli (Alaska) coal; local #1& #2 fuel & waste oil	Wide variety consistent with nationwide averages (hardwood dominates in most states)
Fuel Moisture	Wood fuels sampled in Fairbanks in winter with typical seasoning & moisture; samples preserved for testing; wood sampled for moisture prior to testing; resulting EFs reported "dry basis" (db)	Varies by study ("equilibrium wood moisture" varies by local condition); resulting AP-42 EFs understood to be db, but not reported explicitly; wood heater field studies report 24% avg (db)
Sampling Methods	EPA "Other Test Method 27" for $PM_{2.5}$ (in accordance with EPA proposed changes to method 201A); other EPA methods for gases	Wide variety of primarily EPA methods; most commonly reported as Method 5H or "5H equivalents"
Fuel Loadings:		Fuel loadings & form factor vary by study (AP-42 predates Method 28)
Wood	Method 28 for wood fuel amounts & handling but used Alaskan cord woods rather than Douglas Fir crib wood;	
Liquid Fuels	No EPA test method; followed manufacturers' operating instructions; extended test duration to collect sufficient PM for analysis	
Coal	No EPA test method for stoves; followed manufacturers' operating instructions	
Firing Rates	OMNI targeted 35% & max firing rates (OMNI's "low" and "high" firing generally corresponds to Method 28 categories 3&4, respectively; category 3 is predominant mode for "winter season heating")	Varies by study; may be skewed toward "higher than average in-home burn rate"

One important limitation of the OMNI test program was the number of tests, which was limited by budget constraints to 35. This is far less than the AP-42 sample, which may number in excess of 1,000 tests. However, unlike AP-42, all of the OMNI tests used Alaska-specific fuels and the appliances tested were specifically chosen by OMNI to represent the Alaskan appliance population. Thus, there is a tradeoff between sample size, which favors using AP-42 emission factors, and data specificity, which favors the available OMNI test results.

A second limitation of the OMNI testing was the lack of replicate tests. However, this was partially compensated by the study design, which provided for multiple tests of individual appliances using different fuels and firing rates.

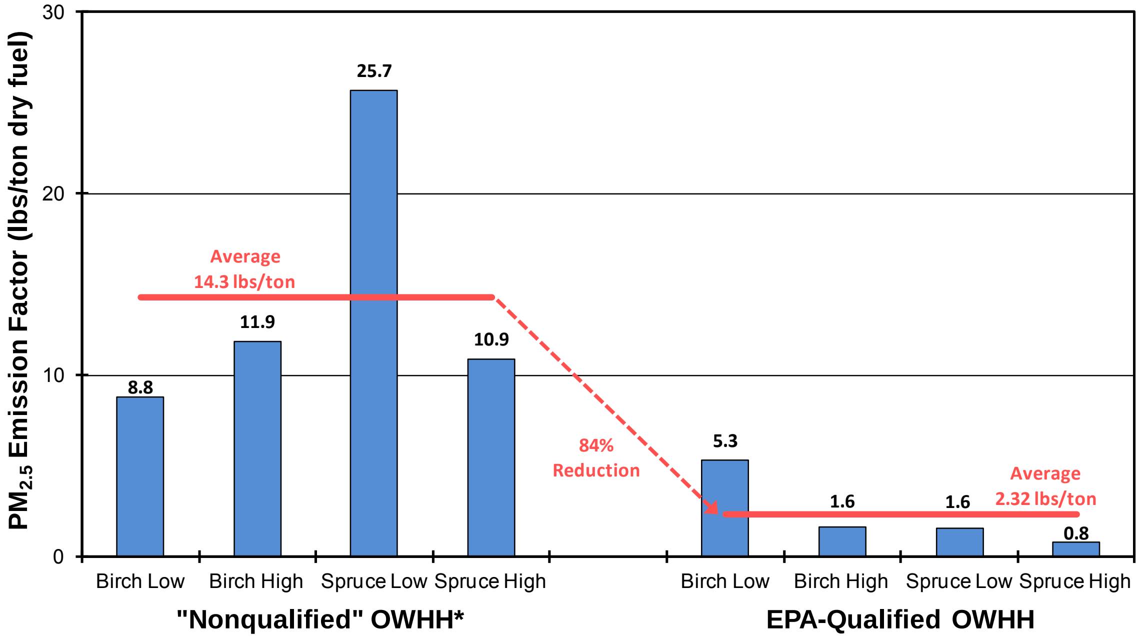
Summary of OMNI Test Results - As shown in Figure 5.6-30 and Figure 5.6-31, the OMNI study design allowed for suspected systematic variations in emissions to be tested and documented, and the observed patterns in the test results give confidence about the repeatability of testing. The figures show not only that EPA-certified wood stoves and EPA-qualified OWHHs emit about 70% less and 84% less $PM_{2.5}$ than their non-certified/nonqualified counterparts, but also that the patterns of reductions are similar for each fuel and firing rate.

Figure 5.6-30
$PM_{2.5}$ Emission Factors from OMNI Testing for Conventional (left) & EPA-Certified (right) Wood Stoves by Wood Species and Firing Rate



Several apparent deviations from a completely systematic variation, such as higher Spruce vs. Birch emissions for the non-qualified OWHH in Figure 5.6-31, are discussed further in the OMNI report[29]. It should also be noted that the figures each show simple averages across the set of high and low firing rate tests.

Figure 5.6-31
$PM_{2.5}$ Emission Factors from OMNI Testing for
Non-Qualified (left) & EPA-Qualified (right) OWHHs by Wood Species and Firing Rate



Based on the greater specificity and applicability to Fairbanks and the greater amount of current supporting detail available, the OMNI emission factors were selected for use in the Fairbanks $PM_{2.5}$ SIP to represent average emissions from residential wood burning units, except for fireplaces (which OMNI did not test). In particular, the average $PM_{2.5}$ emission factors for "low" firing rate tests of birch and spruce were used to characterize the average emission factors for conventional woodstoves and outdoor hydronic heaters, advanced (i.e., more modern) EPA-certified woodstoves, EPA phase 2 qualified OWHHs; and results from OMNI testing with locally produced Alaska wood pellets were used to characterize pellet stoves. The low firing rate tests were used to develop the SIP emission factors because the low firing rate (35% of maximum) was close to that of the winter season average Method 28 firing rate of 34% as explained earlier and based on local evidence suggesting wood burning devices tend to have their air dampers set at a low/mostly closed position to extend burn durations of a fuel load (e.g. to avoid waking up at night to add more wood to a stove).

The birch and spruce test results were weighted together based on splits in commercial timber sales within the Borough obtained from the Alaska Department of Natural Resources, Division of Forestry. These relative splits were 52% birch, 6% spruce and 42% aspen. (The normalized relative splits between birch and spruce were 90% and 10%, respectively).

Emission Factors for Oil-Fired Devices

The vast majority of households in Fairbanks have central oil furnaces and, according to recent telephone survey data, about two-thirds of the residential heating in Fairbanks (BTU basis) is by central oil burning systems. Therefore, despite its relatively low PM emissions factor compared to wood, testing of a central heater with Nos. 1 and 2 heating oils (used in Fairbanks in about a 1:3 ratio) and of a waste (motor) oil-fired space heater were included in OMNI's test program.

The same suite of pollutants was sampled for oil burners as for wood, but the key pollutant of interest for oil burners was SO_2, due to both the much higher concentration of sulfur found in oil and the predominance of oil burning in Fairbanks. EPA's emission factor guidance document, AP-42, states: "On average, more than 95% of the fuel sulfur is oxidized to SO_2, about 1 to 5 percent is further oxidized to sulfur trioxide (SO_3), and 1 to 3 percent is emitted as sulfate particulate." According to EPA's $PM_{2.5}$ SIP guidance, SO_2 is presumed to be a precursor of secondary $PM_{2.5}$. Thus, oil burning appliances may contribute to both primary and secondary $PM_{2.5}$ sulfate in the atmosphere.

Samples of Nos. 1 and 2 fuel oil and waste oil sample were collected by FNSB staff, analyzed for OMNI by SwRI, and found to have sulfur contents of 896, 2566, and 3020 ppm by weight, respectively as shown in Table 5.6-39. Also shown in the table are three alternative SO_2 emission factors (Columns 1–3), all of which are in units of grams of SO_2 emitted per kg of oil burned.

Table 5.6-39
Fuel Sulfur and SO_2 Emission Factors for Three Fairbanks Oil Samples

Fuel	ppm Sulfur (by weight) from SwRI	Alternative SO_2 Emission Factors: (grams of SO_2 per kg of fuel burned)		
		Column 1 Range, assuming 95-100% of fuel S emitted as SO_2	Column 2 All fuel S Emitted as SO_2 except as measured in reduced form on $PM_{2.5}$ filters by XRF	Column 3 EF from OMNI SO_2 (and other) measurements
No. 1 Fuel Oil	896	1.70 - 1.79	1.77	1.25
No. 2 Fuel Oil	2,566	4.88 - 5.13	5.12	2.10
Waste Motor Oil	3,020	5.74 - 6.04	5.93	4.76

Column 1 shows the range of emission factors based strictly on the SwRI-measured sulfur contents and on the 95-100% S to SO_2 conversion rate for oil combustion documented in AP-42. Column 2 shows the corresponding emission factor based on 100% oxidation of sulfur but after first subtracting the PM reduced, elemental sulfur contributions on OMNI's PM filter samples (measured by Research Triangle Institute). These data are confirmatory regarding the SO_2

fraction in that they fall within the range anticipated based on AP-42. The third column shows an independent measure of the SO_2 emission factor by OMNI, although in this case, the EFs for all three oils are below the levels anticipated based on fuel sulfur content, suggesting these measurements are suspect. The precise reason for the lower values in OMNI's SO_2 measurement-based factors is not known, but it is recognized that the latter approach is a more complex estimate because it requires accurate calibration and measurement of not only SO_2 in the dilution tunnel, but also the same for a tracer gas in both the hot appliance stack and the dilution tunnel, along with accurate alignment of all measurement traces.

Two final points are worth noting with respect to oil combustion emission factors. First, the emission factors for SO_2 and SO_3 shown in AP-42's Table 1.3-1 imply a slightly higher proportion of fuel S emitted as SO_2 for residential furnaces (98.9%) than for other fuel burning sources. This is consistent with and lends credence to the relatively high SO_2 fractions (i.e., small PM correction) observed from the OMNI/SwRI/RTI measurements. Second, the oil burners were designed for and emission tested by OMNI at a single firing rate (there were no firing rate issues such as occurred with the wood burning appliances).

Based on the above findings, it was concluded that the simplest and most consistent emission factor for SO_2 is that derived from the direct fuel sulfur based method as reflected in AP-42. Accordingly, application of the fuel sulfur based method with 100% SO_2 oxidation and using the SwRI fuel sulfur measurements for oil, has been assumed in developing the Fairbanks SIP emissions inventory. By comparison, the emission factor measurement of SO_2 by OMNI is more complicated and may be less reliable than the above method. Furthermore, considering the closeness of the OMNI PM sulfur adjusted values (column 2) to the 100% S conversion based EFs (upper range limit of Column 1), the latter were used for the SIP-based inventory without adjustment for sulfur in the PM.

Emission Factors for Coal-Burning Devices

In addition to wood and oil fuels, OMNI emission tested Alaskan (Usibelli) subbituminous coal (wet, dry, lump, and stoker) in several residential heaters. Currently, coal is not widely used as a residential heating fuel in Fairbanks, and no EPA source test methods exist for residential coal stoves. The only AP-42 emission factor data available are from testing of much larger coal-fired boilers.

Under contract to OMNI, Twin Ports Testing (TPT) analyzed Alaskan coal samples that had been collected by Borough staff, stored in sealed drums to maintain moisture, and then shipped and stored by OMNI for use in testing. TPT reported that lump and stoker coal have sulfur content of 0.086 and 0.101 weight % S (dry basis), respectively. Fuel moisture contents for the eight coal test charges measured by OMNI immediately prior to testing ranged from 11.20–33.50%.

With regard to $PM_{2.5}$ emissions, coal emission factors were (unlike cordwood emission factors) somewhat variable, depending upon the device tested, wet vs. dry fuel, fuel form factor, firing rate, and other test conditions.

For lack of any information from AP-42 on residential coal burning, emission factors used to develop the Fairbanks inventory were taken from the OMNI test results, using the average of all valid tests at low firing rate (which is close to the expected heating season average firing rate).

Emission Factors for Other Pollutants

In addition to measuring $PM_{2.5}$ and SO_2, OMNI also measured and developed emission factors for VOC, CO, NO, NO_2, NO_x, and NH_3 for all wood-burning devices and oil furnaces. For those cases where the OMNI study has provided more specific and applicable measurements than what is available from AP-42, Sierra has recommended the use of the former, with the two exceptions of SO_2 (discussed above) and VOC. For VOC, OMNI's measurements and emission factor are presented on a carbon mass-basis, whereas AP-42 shows mass emissions for TOC, methane, TNMOC, selected organic species, PAHs, and more. Absent more detailed information about the C-mass fraction of both sources, comparison of the VOC emission factors is problematic. Thus no attempt was made to compare OMNI's emission factors with those in AP-42, nor consider substitution of the OMNI EF's for those in AP-42.

SIP Inventory Emission Factors

Table 5.6-40 and Table 5.6-41 provide tabulations of the emission factors used to estimate space heating emissions for the SIP inventories. These tables respectively show emission factors for wood-burning (in lbs/ton) and for other heating types (in lbs/1000 gals). The first column in each table lists the device type/technology. The next seven columns list the emission factors for VOC, NO_x, SO_2, primary PM_{10} and $PM_{2.5}$, NH_3 and CO.

The last column in each table lists the data source(s) and, in several cases, provides additional details about the emission factor calculations. Further details are provided in the footnotes to individual emission factor entries. Highlighted cells in each tables show emission factor entries that are based on OMNI results. Unshaded cells refer to "default" AP-42 based emission factors that were used where OMNI data were not available or insufficient.

Table 5.6-40
Emission Factors for Wood-Burning Devices (lbs/ton) - EPA Method 5H Except Where Noted (OMNI Factors in Highlighted Cells)

Device and Technology	VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$	NH_3	CO	Data Source(s)
Fireplace, no insert	229.0	2.6	0.4	34.6	34.6	1.8[32]	252.6	AP-42, Table 1.9-1; for SO2, OMNI fuel S for spruce gave same EF as AP-42
Fireplace insert, non-EPA certified	53.0	2.8	0.4	30.6	30.6	1.7	230.8	Assumed equal to uncertified woodstove EFs
Fireplace insert, EPA-certified, non-catalytic.	12.0[33]	2.0[33]	0.4[33]	12.0	12.0	0.9[33]	140.8[33]	AP-42, Table 3 for PM EFs www.epa.gov/ttnchie1/ap42/ch01/related/woodstoveapp.pdf
Fireplace insert, EPA-certified catalytic	15.0[33]	2.0[33]	0.4[33]	13.0	13.0	0.9[33]	107.0[33]	AP-42, Table 3 for PM EFs www.epa.gov/ttnchie1/ap42/ch01/related/woodstoveapp.pdf
Woodstove, non-EPA certified	53.0	1.4	0.4	11.60[34]	11.60[34]	0.379	115.8	AP-42, Table 1.10-1 for VOC&SO_2; others use avg of OMNI runs 14&15, conventional wood stove, spruce & birch, low firing rate
Woodstove, EPA-certified, non-catalytic	12.0	1.5	0.4	7.57[34]	7.57[34]	0.239	118.1	AP-42, Table 1.10-1,assmd Phase II (1990 stds) for VOC&SO_2; others use avg OMNI runs 5&6 for birch & spruce; EPA (non-cat) woodstove low firing rate
Woodstove, EPA-certified, catalytic	15.0	1.5	0.4	8.40[34]	8.40[34]	0.239	118.1	same as immediately above, except OMNI avgs for PM_{10}&$PM_{2.5}$ scaled by the ratio of cat to non-cat (16.2/14.6)
Pellet Stove, exempt	2.4[35]	4.0	0.32	2.96	2.96	0.072	9.9	AP-42, Table 1.10-1for VOC; all others OMNI run #1, pellet stove, except SO_2 which is based on dry pellet S content from OMNI
Pellet Stove, EPA-certified	2.4[35]	4.0	0.32	2.96	2.96	0.072	9.9	AP-42, Table 1.10-1for VOC; all others OMNI run 1, pellet stove, except SO_2 which is based on dry pellet S content from OMNI
Hydronic Heater, weighted 80/20	*45.4*	*1.5*	*0.4*	9.43	9.43	0.233	*57.9*	80% / 20% weighting of OWB unqualified&OWB-Ph2 qualified
Hydronic Heater, Unqualified	*53.0*	*1.4*	*0.4*	10.55[34]	10.55[34]	0.261	*52.8*[36]	EPA/NY for VOC&SO_2; others use avg of OMNI runs 30&32, OWHH birch &spruce, low firing rate OMNI dry S content for spruce same EF as AP-42
Hydronic Heater, Phase 1	*12.0*	*2.1*	*0.4*	9.303[34]	9.30[34]	0.120	*102.7*	set rates for VOC to those for woodstoves; others from avg of OMNI runs 9&11, spruce & birch, EPA qualified OWHH, low firing rate, but for PM&CO scaled by phase 1&2 ratio;SO_2 based on OMNI content of dry spruce
Hydronic Heater, Phase 2	*15.0*	*2.1*	*0.4*	4.94[34]	4.94[34]	0.120	*78.01*	set rates for VOC to those for woodstoves; others from avg of OMNI runs 9 and 11, spruce & birch, EPA qualified OWHH, low firing rate, but PM & CO scaled by ratio for phase 1&2;SO_2 based on OMNI S content of dry spruce

[32] NH_3 EF from Pechan "Estimating Ammonia Emissions from Anthropogenic Non-Agricultural Sources", Draft Final Report, April 2004.
[33] No separate EF data for this pollutant; assumed equal to corresponding certified woodstove EFs from AP-42.
[34] Entries reflect weighting of spruce and birch EFs from wood-specific OMNI tests based upon spruce vs. birch sales split from US Forest Service timber sales data
[35] From http://www.epa.gov/burnwise/pdfs/EPA_stove_emis_reduct.pdf, converted from kg/tonne to lbs/ton.
[36] CO is lower limit because instrument pegged.

Table 5.6-41
Emission Factors for Other Devices (lbs/1000 gal except where noted, OMNI Factors in Highlighted Cells)

Other Heating Types	VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$	NH_3	CO	Data Source(s)
Central Oil (Wtd #1 & #2), Residential	0.713	11.2	30.71[37]	0.457	0.457	0.024	0.448	AP-42 Table 1.3-1 for VOC; OMNI fuel S content for SO_2; all others OMNI run#17,SwRI for fuel (lower) heating value,AP-42 for fuel oil density
Central Oil (#1 distillate), Residential	0.713	11.2	12.72[38]	0.457	0.457	0.024	0.448	AP-42 Table 1.3-1 for VOC; OMNI fuel S content for SO_2; all others OMNI run#17, SwRI for fuel (lower) heating value,AP-42 for fuel oil density
Central Oil (#2 distillate), Residential	0.713	11.2	36.44[39]	0.457	0.457	0.024	0.448	AP-42 Table 1.3-1 for VOC;OMNI fuel S content for SO_2; all others OMNI run#17, SwRI for fuel (lower) heating value,AP-42 for fuel oil density
Central Oil (Wtd #1 & #2), Commercial	0.713	18	30.71[6]	0.457	0.457	0.024	0.448	AP-42 Table 1.3-1 for NO_x; for all others, assume same as above
Portable Heater: 43% Kerosene & 57% Fuel Oil	0.713	18	30.71[6]	0.4	0.4	0.024	0.4	EFs for portable heaters w. kerosene/fuel oil #2 blend assumed equal to central oil (#2); all except SO_2, NH_3 and CO, assumed same as above
Direct Vent	0.713	11.2	12.72	0.5	0.5	0.024	0.4	EFs for DV w. #1 assumed equal to central oil (on #2) in absence of actual data; except SO_2, NH_3 and CO assumed same as above
Natural Gas-Residential	5.5	94	0.6	1.9	1.9	20	40	AP-42 Tables 1.4-1 & 1.4-2 for all but NH_3; EPA/Pechan for NH_3
Natural Gas-Commercial, small uncontrolled	5.5	100	0.6	1.9	1.9	20	40	AP-42 Tables 1.4-1 & 1.4-2 for all but NH_3, EPA/Pechan for NH_3
Coal Boiler	10	4.7	9.3[40]	8.0	8.0	1.266	130.6	AP-42 Table 1.1-19 for VOC, (w. Usibelli S content) SO_2; OMNI runs 21,23,37&38 for other, coal stove, wet & dry stoker & lump coal, low firing rate
Waste Oil Burning	1	52.2	36.97	5.2	5.2	0.036	12.4	AP-42 Table 1.11-1 for VOC; all others OMNI run#18, SwRI for heating value, AP-42 for No. 2 fuel oil density

[37] Assumes fuel S content of 2,163 ppm by weight; reflects approximate 76/24 split of #2/#1 per information from Polar & Sourdough Fuels; ADEC email 1/31/12.
[38] Assumes S content of 896 ppm of #1from SWRI analysis of Fairbanks fuel sample as reported by OMNI Labs.
[39] Assumes S content of 2566 ppm of #2 from SWRI analysis of Fairbanks fuel sample as reported by OMNI Labs.
[40] Assumes coal S content of 0.3% by weight per www.Usibelli.com/coal_data.asp .

Space Heating – Emission Calculation Details

Home heating (and commercial space heating) emissions were calculated in a manner that optimized the use of locally-collected survey data, in-use device activity and fuel use measurements, and emission factor data that were described in detail in the preceding sections of this technical appendix. This section of the appendix explains how these local data were used in conjunction with the Fairbanks space heating energy model to generate estimates of pollutant emissions used in the episodic inventories. Thus, a key element in these emission inventory calculations consisted of utilizing spatially- and temporally-resolved data or relationships based on them to generate gridded, day and hour-specific estimates of space heating emissions over the modeling domain.

These calculations were performed in a series of complex "Space Heating" spreadsheets with the following filename convention:

G3C_SpHtArea_*YYYY***F***Case***_11Tag_Episodes.xlsm**

Where *YYYY* is the inventory year (2008, 2015 or 2019) and *Case* refers to whether the estimates represent the baseline (Base) or the projected baseline (PB), the latter under which additional logic regarding activity growth and other factors is applied.

(These spreadsheets and all other inventory data files are summarized later in the "Emission Inventory Data Files" sub-section within this appendix and are available by request from the Alaska Department of Environmental Conservation.)

Energy Model Implementation

The first step in building the Space Heating emission calculation spreadsheets consisted of loading in the Fairbanks Home Heating Energy Model in order to compute needed household heating energy as a function of device/fuel mix, building size, average daily ambient temperature and day type (weekday vs. weekend). The *Coeffs* tab in the spreadsheet contains the daily and hourly energy model coefficients listed earlier in Table 5.6-7 and Table 5.6-8.

The energy model is then implemented within the *HtEnergy* tab to calculate heating energy by modeling grid cell for each of the 1.33 km square cells across the modeling domain based on the number of residential households in each cell determined from block-level 2010 U.S. Census data (and grown forward or backward to each inventory year based on population projections). The summed space heating energy over all households in each grid cell was calculated separately by day and hour for each based on ZIP code-specific winter season energy use splits by device/fuel type developed the 2011 Home Heating Survey.

Table 5.6-42 (identical to Table 5.6-28 shown earlier) shows these winter season energy use splits by ZIP code. Those device/fuel types highlighted in Table 5.6-42 represent those for which space heating energy use is estimated from the energy model. (Their normalized subtotals are also shown near the bottom of Table 5.6-42.)

Table 5.6-42
Winter Season Energy Use Splits by ZIP Code for Energy Model Input

Fuel Group	Device/Fuel Type	Pct. of Winter Season Energy Use by ZIP						Census Wtd. Avg.
		99701	99703	99705	99709	99712	99775	
Wood-Burning	1 – Stoves	7.65%	23.37%	20.75%	21.19%	21.92%	11.50%	17.67%
	2 – Fireplaces	0.49%	0.03%	0.77%	0.99%	0.03%	0.03%	0.62%
	3 – OWBs	1.95%	1.15%	7.58%	3.69%	1.58%	1.15%	4.41%
Oil-Burning	4 - Central Oil	78.98%	60.66%	63.64%	65.06%	62.49%	84.42%	66.20%
	5 - Direct Vent Heat	3.19%	3.40%	4.11%	5.92%	10.60%	1.78%	6.14%
	Portable Heaters	1.41%	0.83%	1.56%	0.56%	0.85%	0.36%	1.24%
Natural Gas	Natural Gas Heat	5.46%	9.99%	1.12%	1.21%	1.71%	0.63%	2.79%
Coal	Coal Heaters	0.58%	0.13%	0.45%	0.30%	0.77%	0.13%	0.52%
Electric	Electric Heat	0.29%	0.42%	0.01%	1.08%	0.05%	0.01%	0.41%
Instrumented Study Subtotals		92.26%	88.62%	96.86%	96.86%	96.62%	98.87%	95.04%
Totals		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Space heating energy use for those device/fuel types not highlighted (Portable Oil Heaters, Natural Gas, Coal and Electric Heat) was estimated from their Home Heating Survey-based splits shown in Table 5.6-42 in proportion to their Survey-based energy use outside the energy model. For example, if per-household energy use for a grid cell in ZIP code 99701 (Fairbanks) was 500,000 BTU/day for devices accounted for by the energy model (listed as devices 1 through 5 in Table 5.6-42), then per-household heating energy from coal devices would be estimated as (0.58% × [500,000 ÷ 92.26%]) = 3,143 BTU/day.

These calculations are performed within the context of the gridded modeling inventories in a manner in which space heating energy use is not calculated by individual device (or household), but rather based on the total number of households in each grid cell and the average device/fuel usage splits across all surveyed households within each ZIP code. For ZIP codes not included in the Home Heating Survey (which sampled households only within the non-attainment area), the Census weighted average splits in the rightmost column of Table 5.6-42 were used.

Another element considered in calculating space heating energy use by episode day and hour for each grid cell was the use of occupied vs. total (which includes occupied and vacant households) households counts from the 2010 Census. Based on discussions with Borough staff, wood and coal burning energy use was calculated based on occupied households, while energy use for other devices/fuel was based on total (occupied and vacant) households. The central assumption here was that thermostatically-controlled devices (central oil, natural gas) would still be operated at some lower heating level to ensure interior pipes and other infrastructure would not freeze and crack. No adjustment was estimated to account for the lower heating level for these devices in vacant households.

Finally, parcel level GIS data developed by the Borough from tax assessment data was used to calculate the average building size (in heated interior area) separately for both residential and commercial parcels within each grid cell. These average building sizes for each grid cell were required to drive the energy model calculations (along with average daily temperature, device usage mix and day type).

Application of Energy-Specific Emission Factors

The next step in the calculation of space heating emissions consisted of converting the device and technology specific emission factors presented earlier in Table 5.6-40 and Table 5.6-41 from pounds emitted per fuel use unit to pounds emission per unit energy (i.e., pounds per million BTU or lb/mmBTU). This conversion was necessitated by two factors:

1. *BTU-Based Energy Model* - The energy model was configured to predict space heating energy use (in BTUs), rather than fuel use across all of the devices. (This made it easier to utilize relative energy use splits calculated from the Home Heating Survey to augment energy use estimates for device not addressed directly within the energy model.)

2. *Treatment of Wood Moisture Effects* – Unlike other fuels used for space heating, the effective or "heating" energy of wood is directly related to its moisture content as discussed earlier in the "Home Heating – Fairbanks Wood Energy and Moisture Effects" section. The space heating emission calculation workflow (and adjustments for wood moisture) was made much simpler by starting with emission factors for wood devices assuming zero or oven dry moisture content and then applying a multiplicative adjustment that accounted for the heating energy effect as a function of moisture content. (This also made the process for calculating future inventories reflecting either trends in moisture content or effects from planned or adopted control measures more straightforward.)

The emission factor conversions were performed by dividing fuel specific energy content presented earlier in Table 5.6-26 (in BTU/fuel unit) into the pound per fuel unit emission factors in Table 5.6-40 and Table 5.6-41. For example, the $PM_{2.5}$ emission factor for residential heating oil (with mix of #1 and #2 oil) from Table 5.6-41 of 0.457 lb/1000 gal was divided by the energy content for heating oil (with the #1 and #2 mix) of132,000 BTU/gal (or 132 mmBTU/1000gal) listed in Table 5.6-26 to yield and energy-specific emission factor of 0.000346 (3.46×10^{-3}) lb/mmBTU.

Table 5.6-43 and Table 5.6-44 present the results of these emission factor conversions for all wood and non-wood burning devices and technologies, respectively. As noted above, energy-specific wood burning emission factors in Table 5.6-43 are represented on an over dry or 0% moisture basis. In both tables, highlighted cells refer to emission factors based on local device/fuel measurements from the OMNI Labs testing study; AP-42 factors were used for pollutant/device combinations in un-highlighted cells. SCC codes and assumed net heating efficiencies for each device are also shown in both tables. Although the heating efficiencies were not used in calculating baseline emissions, they are used later in Control inventory calculations where efficiency were accounted for in scenarios where heating devices are replaced by other device, such as switching from wood to heating oil.

Table 5.6-43
Heating Energy-Specific Emission Factors for Wood-Burning Devices (lbs/mmBTU), Oven Dry (0%) Moisture Basis (OMNI-Based Factors in Highlighted Cells)

Device and Technology	SCC Code	Heating Efficiency	Emission Factors (lb/mmBTU)						
			VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$	NH_3	CO
Fireplace, no insert	2104008100	7%	13.237	0.150	0.023	2.000	2.000	0.104	14.601
Fireplace insert, non-EPA certified	2104008210	40%	3.064	0.162	0.023	1.769	1.769	0.098	13.341
Fireplace insert, EPA-certified, non-catalytic.	2104008220	66%	0.694	0.116	0.023	0.694	0.694	0.052	8.139
Fireplace insert, EPA-certified catalytic	2104008230	70%	0.867	0.116	0.023	0.751	0.751	0.052	6.185
Woodstove, non-EPA certified	2104008310	54%	3.064	0.085	0.023	0.714	0.714	0.023	7.129
Woodstove, EPA-certified, non-catalytic	2104008320	68%	0.694	0.095	0.023	0.466	0.466	0.015	7.274
Woodstove, EPA-certified, catalytic	2104008330	72%	0.867	0.095	0.023	0.517	0.517	0.015	7.274
Pellet Stove, exempt	2104008410	56%	0.139	0.247	0.020	0.182	0.182	0.004	0.612
Pellet Stove, EPA-certified	2104008420	78%	0.139	0.247	0.020	0.182	0.182	0.004	0.612
Hydronic Heater, weighted 80/20	2104008610	43%	2.624	0.095	0.023	0.581	0.581	0.014	3.563
Hydronic Heater, Unqualified	2104008610	43%	3.064	0.087	0.023	0.650	0.650	0.016	3.253
Hydronic Heater, Phase 1	2104008610	43%	0.694	0.127	0.023	0.573	0.573	0.007	6.321
Hydronic Heater, Phase 2	2104008640	43%	0.867	0.127	0.023	0.304	0.304	0.007	4.804

Table 5.6-44
Heating Energy-Specific Emission Factors for Other Devices (lbs/mmBTU) (OMNI-Based Factors in Highlighted Cells)

Device and Technology	SCC Code	Heating Efficiency	Emission Factors (lb/mmBTU)						
			VOC	NO_x	SO_2	PM_{10}	$PM_{2.5}$	NH_3	CO
Central Oil (Wtd #1 & #2), Residential	2104004000	81%	5.40E-03	8.46E-02	2.33E-01	3.46E-03	3.46E-03	1.86E-04	3.39E-03
Central Oil (#1 distillate), Residential	2104004000	81%	5.70E-03	8.94E-02	1.02E-01	3.65E-03	3.65E-03	1.96E-04	3.58E-03
Central Oil (#2 distillate), Residential	2104004000	81%	5.15E-03	8.07E-02	2.63E-01	3.30E-03	3.30E-03	1.77E-04	3.23E-03
Central Oil (Wtd #1 & #2), Commercial	2103004001	81%	5.15E-03	1.30E-01	2.22E-01	3.30E-03	3.30E-03	1.77E-04	3.23E-03
Portable Heater: 43% Kerosene & 57% Fuel Oil	2104004000	81%	5.20E-03	1.31E-01	2.24E-01	2.92E-03	2.92E-03	1.79E-04	3.27E-03
Direct Vent	2104007000	81%	5.70E-03	8.94E-02	1.02E-01	3.65E-03	3.65E-03	1.96E-04	3.58E-03
Natural Gas-Residential	2104006010	81%	5.42E-03	9.26E-02	5.91E-04	1.87E-03	1.87E-03	1.97E-02	3.94E-02
Natural Gas-Commercial, small uncontrolled	2103006000	81%	5.42E-03	9.85E-02	5.91E-04	1.87E-03	1.87E-03	1.97E-02	3.94E-02
Coal Boiler	2104002000	43%	6.54E-01	3.08E-01	6.08E-01	5.22E-01	5.22E-01	8.27E-02	8.53E+00
Waste Oil Burning	2102012000	n/a	7.22E-03	3.77E-01	2.67E-01	3.76E-02	3.76E-02	2.63E-04	8.97E-02

n/a – Not available

In applying these energy-specific emission factors in the Space Heating calculation spreadsheets, it was necessary to apply additional usage splits or allocations for each of the technologies listed in Table 5.6-43 and Table 5.6-44. For example, to calculate separate emission estimates for wood devices burning cordwood versus pellets and to allocate the splits of uncertified and certified wood stoves and inserts. Table 5.6-27 and Table 5.6-29 presented earlier in the "Home Heating - Residential Surveys" section contain these cordwood/pellet and uncertified/certified device splits.

Notwithstanding wood moisture adjustments discussed separately in the next sub-section, space heating emissions were then calculated within each grid cell (by day and hour) by multiplying the total BTUs by device in the cell by the device and technology-specific energy emission factors listed in Table 5.6-43 and Table 5.6-44.

The emission calculations for each grid cell were performed with the *Emis* tab in the Space Heating calculation spreadsheets.

Wood Moisture Adjustment Calculations

As explained earlier in the "Home Heating – Fairbanks Wood Energy and Moisture Effects" section, wood moisture effects were accounted for using a linear relationship of heating BTUs vs. moisture content. This adjustment was necessary in calculation of 2008 Baseline and 2015 and 2019 Projected Baseline space heating emissions because of trends in average moisture content developed from survey data as described in that earlier section. Thus, with emission factors for wood devices expressed on a lb/mmBTU oven dry basis, it was relatively straightforward to apply the moisture adjustments, given an "input" or assumed average moisture level across all grid cells.

The *Moisture* tab in the Space Heating emission calculation spreadsheets contains the wood moisture content adjustment calculations based on the methods described in the earlier "Home Heating – Fairbanks Wood Energy and Moisture Effects" section. It also accounts for the fact that wood use measurements (and heating energy estimates developed from them embedded in the Home Heating Energy Model are associated with a specific wood moisture content of 26.6% (on a dry basis). Thus, the energy estimates from the model had to be adjusted to an oven dry basis from this 26.6% "reference" moisture level. In addition, the *Moisture* tab also includes an adjustment to account for the difference between the assumed wood energy content when the energy model was developed (6,053 BTU/lb) and that developed later in the SIP inventory process from the aforementioned 2013 Wood Tag Survey (6,413 BTU/lb at the 26.6% reference moisture level).

Commercial Space Heating Emissions

Due to differences in energy efficiency, ceiling heights and overall building size the residential Home Heating Energy Model was not used to estimate space heating energy use and emissions within commercial buildings.

Instead commercial sector heating energy was calculated based on an estimate of commercial building space energy intensity in Alaska provided by CCHRC.[41] CCHRC compared an energy model they developed using the ASHRAE "Energy Standard for Buildings Except Low Rise Residential Buildings" Standard 90.1. Using the ASHRAE minimum standard (referred to as ECB) our Research Testing Facility, which is primarily office space, CCHRC found an energy intensity of about 89,000 BTU/ft^2/yr for its office building in Fairbanks.

Looking at the 2003 US Commercial Building Energy Consumption Survey (CBECS) published by the U.S. Energy Information Administration, commercial building energy loads in Climate Zone 1 (Alaska) CCHRC found the most representative estimate to be 90,690 BTU/ft^2/yr, which closely agrees with the estimate for their own office building. This CBECS value of 90,690 was assumed to best represent average annual heating energy intensity of commercial structures in Fairbanks.

To use this annual intensity within the episodic inventory, the average of number of heating degree days (HDD) referenced to 65°F in Fairbanks was estimated to be 14,274 HDD based on data compiled for Fairbanks International Airport by Weather Underground[42]. Dividing this local HDD into the annual commercial building intensity for Fairbanks yields an estimate of 6.35 BTU/HDD/ft^2. This HDD-normalized building energy intensity was then used to calculate commercial heating energy demand within each grid cell. This was done by summing the total building space of all commercial structures within each grid cell developed from parcel-level Assessor data supplied by the Borough and then multiplying by the daily HDD for each day in the historical modeling episodes and the HDD-normalized intensity as follows:

$$Energy_{x,y} = 6.35\ BTU/HDD/ft^2 \times HDD_i \times Buildings \times Avg\ Size\ (ft^2)$$

Where:

$Energy_{x,y}$ is the total commercial building heating energy estimated for grid cell (x,y) on episode day *i* (in BTU/day), HDD_i is the heating degree days for day *i* (referenced to 65F), *Buildings* represent the number of commercial structures in the grid cell and *Avg Size* is the average commercial building size (in ft^2).

These daily estimates for each grid cell were then apportioned to hourly values using an average hourly energy use profile for oil-heating devices within the energy model (assuming commercial building are similarly thermostatically controlled).

Commercial space heating energy use was assumed to be allocated to two fuel types: 1) heating oil; and 2) natural gas. Based on usage data compiled for Fairbanks under the aforementioned "Big 3" inventory study a split of 98% oil and 2% natural gas was assumed. The commercial device emission factors for oil and natural gas heating shown earlier in Table 5.6-44 were then used to compute commercial space heating emissions within each grid cell.

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[41] Email from Colin Craven, Cold Climate Housing Research Center, April 27, 2009.
[42] www.degreedays.net (using temperature data from www.wunderground.com)

Calculation Workflow

Given the calculation complexity of the Space Heating emission spreadsheet, it was set up in a manner in which the following “inputs” were specified in two shaded cells within the *Emis* tab:

- *Scenario* – Either “FBASE” for final 2008 baseline or “PB” for projected baseline, which triggered different logic used to calculate baseline emissions or project emissions to future years that included adjustments for trends in moisture level from the 2008 baseline and in natural turnover of uncertified wood stoves and inserts.

- *Calendar Year* – The inventory calendar year (2008, 2015 or 2019).

A Visual Basic for Applications (VBA) program written within the spreadsheet was then used to cycle through and calculate emissions for each day of the two modeling episodes. When emissions for each day were calculated within the *Emis* tab, they were translated to data structures in two other sheets in formats required by the SMOKE inventory processing model and then exported by the VBA program to external fixed-length ASCII files for subsequent input to SMOKE. In addition, emission estimates were automatically copied by the VBA program to a series of tabulation sheets (e.g., *DevTabs, ZipTabs, GridTabs, DevSumOut*) as calculations were being performed for each episode day.

Use of Episodic Emissions in SMOKE Model

As explained in greater detail in Appendix III.D.5.8, a re-written version of the SMOKE Version 2.7.1 was used to provide space heating emissions to the pre-processor model on an episodic day and hour basis. Although the SMOKE model as originally written allowed point source emissions to be input by individual day and hour, area source emission categories (such as space heating) had to be temporally allocated using a combination of monthly, weekday and hourly profiles that would have lost the individual day- and hour-specific resolution reflected in the calculation of space heating emissions.

In short, the source code was modified in several locations to allow SMOKE to utilize space heating emission inputs by day and hour identically to its handling of episodic point source emissions.

OTHER AREA SOURCES

Emission contributions from other area sources in Fairbanks during winter are relatively modest compared to those from space heating. As a result, the methods used to estimate emissions for all other sources within the area source sector (besides space heating) were less complex. However they still relied on local data where it was available, rather than national defaults or a "top-down" approach.

This section of the technical appendix describes the data sources and methods used to estimate emissions from other non-space heating sources within the area source sector, beginning with the primary data source, a criteria pollutant inventory developed under an earlier ADEC study.[43]

FAIRBANKS CRITERIA POLLUTANT INVENTORY

The referenced ADEC 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, Fairbanks North Star Borough and 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, NO_x, CO, SO_x, 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 ADEC to submit data to support the NEI. Only area source SCC records for were extracted for the Fairbanks Borough in calendar year 2005, the nearest year to the SIP inventory 2008 base year.

Figure 5.6-32 and Figure 5.6-33 show the county-wide 2005 Fairbanks winter and summer average day estimates, respectively for area sources extracted by SCC from the Big 3 inventory. Records shaded in gray reflect those SCC's related to space heating. Since space heating emissions were estimated separately under the SIP inventory, these records were excluded from the Other Area Source portion developed from the earlier Big 3 inventory.

Although summer and winter emissions are shown, only the winter estimates were used to support the episodic inventories. Summer estimates (and annual averages developed from the winter and summer seasonal emissions) were utilized to support the "planning" inventories in the SIP. Summer estimates are included here to illustrate what are significant seasonal differences for certain source categories (e.g., wildfires and fugitive dust).

[43] 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.

Figure 5.6-32
2005 "Big 3" Inventory Fairbanks Area Source Emissions (tons/day) by SCC, Average Winter Day

		Winter Emissions (tons/day)						
Source	SCC	VOC	CO	NOx	SOx	NH3	PM10	PM2.5
Area Sources								
Stationary Source Fuel Combustion, Commercial/Institutional, Natural Gas, Total: Boilers and IC Engines	2103006000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stationary Source Fuel Combustion, Residential, Distillate Oil, Total: All Combustor Types	2104004000	0.037	0.260	0.935	2.468	0.000	0.021	0.020
Stationary Source Fuel Combustion, Industrial, Waste oil, Total	2102012000	0.000	0.003	0.011	0.028	0.000	0.000	0.000
Stationary Source Fuel Combustion, Residential, Natural Gas, Residential Furnaces	2104006010	0.001	0.006	0.013	0.000	0.000	0.001	0.001
Stationary Source Fuel Combustion, Residential, Liquified Petroleum Gas (LPG), Total: All Combustor Types	2104007000	0.001	0.003	0.024	0.003	0.000	0.001	0.001
Stationary Source Fuel Combustion, Residential, Wood, Total: Woodstoves and Fireplaces	2104008000	2.381	6.181	0.089	0.016	0.000	0.855	0.855
Mobile Sources, Paved Roads, All Paved Roads, Total: Fugitives	2294000000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives	2296000000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Industrial Processes, Petroleum Refining: SIC 29, Asphalt Paving/Roofing Materials, Total	2306010000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Solvent Utilization, Surface Coating, Architectural Coatings, Total: All Solvent Types	2401001000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Solvent Utilization, Miscellaneous Non-industrial: Commercial, Asphalt Application: All Processes, Total: All Solvent Types	2461020000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, Gasoline Service Stations, Stage 2: Spillage	2501060102	0.004	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, Gasoline Service Stations, Stage 2: Displacement Loss/Controlled	2501060103	0.377	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, All Storage Types: Working Loss, Gasoline	2501000120	0.021	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, All Storage Types: Breathing Loss, Gasoline	2501995120	0.042	0.000	0.000	0.000	0.000	0.000	0.000
Miscellaneous Area Sources, Other Combustion, Forest Wildfires, Total	2810001000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Miscellaneous Area Sources, Other Combustion, Structure Fires, Total	2810030000	0.009	0.108	0.003	0.000	0.000	0.007	0.000
Miscellaneous Area Sources, Other Combustion, Firefighting Training, Total	2810035000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 5.6-33
2005 "Big 3" Inventory Fairbanks Area Source Emissions (tons/day) by SCC, Average Summer Day

		Summer Emissions (tons/day)						
Source	SCC	VOC	CO	NOx	SOx	NH3	PM10	PM2.5
Area Sources								
Stationary Source Fuel Combustion, Commercial/Institutional, Natural Gas, Total: Boilers and IC Engines	2103006000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stationary Source Fuel Combustion, Residential, Distillate Oil, Total: All Combustor Types	2104004000	0.013	0.089	0.319	0.842	0.000	0.007	0.007
Stationary Source Fuel Combustion, Industrial, Waste oil, Total	2102012000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stationary Source Fuel Combustion, Residential, Natural Gas, Residential Furnaces	2104006010	0.001	0.003	0.024	0.003	0.000	0.001	0.000
Stationary Source Fuel Combustion, Residential, Liquified Petroleum Gas (LPG), Total: All Combustor Types	2104007000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stationary Source Fuel Combustion, Residential, Wood, Total: Woodstoves and Fireplaces	2104008000	0.403	1.065	0.015	0.003	0.000	0.148	0.148
Mobile Sources, Paved Roads, All Paved Roads, Total: Fugitives	2294000000	0.000	0.000	0.000	0.000	0.000	23.191	5.615
Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives	2296000000	0.000	0.000	0.000	0.000	0.000	37.398	5.604
Industrial Processes, Petroleum Refining: SIC 29, Asphalt Paving/Roofing Materials, Total	2306010000	0.000	0.020	0.006	0.004	0.000	0.222	0.013
Solvent Utilization, Surface Coating, Architectural Coatings, Total: All Solvent Types	2401001000	1.322	0.000	0.000	0.000	0.000	0.000	0.000
Solvent Utilization, Miscellaneous Non-industrial: Commercial, Asphalt Application: All Processes, Total: All Solvent Types	2461020000	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, Gasoline Service Stations, Stage 2: Spillage	2501060102	0.038	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, Gasoline Service Stations, Stage 2: Displacement Loss/Controlled	2501060103	0.444	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, All Storage Types: Working Loss, Gasoline	2501000120	0.021	0.000	0.000	0.000	0.000	0.000	0.000
Storage and Transport, Petroleum and Petroleum Product Storage, All Storage Types: Breathing Loss, Gasoline	2501995120	0.041	0.000	0.000	0.000	0.000	0.000	0.000
Miscellaneous Area Sources, Other Combustion, Forest Wildfires, Total	2810001000	19.392	412.071	8.840	2.424	1.854	40.066	34.363
Miscellaneous Area Sources, Other Combustion, Structure Fires, Total	2810030000	0.009	0.108	0.003	0.000	0.000	0.007	0.000
Miscellaneous Area Sources, Other Combustion, Firefighting Training, Total	2810035000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(Though not shown in Figure 5.6-32 and Figure 5.6-33, annual average daily emissions were calculated assuming 182-day winter and 183-day summer seasons.)

Source-Specific Big 3 Study Methodologies - Generally speaking, the emissions for the area source sector in the Big 3 inventory were developed by combining seasonally-adjusted local activity estimates with AP-42 emission factors. Excerpts from the Big 3 study report describing these data sources and methods are provided below. Thus it also includes discussions of Anchorage and Juneau elements that were also addressed under the earlier study and provide insight into local data and methods collected for each area, although only Fairbanks elements were utilized for this SIP inventory.

Fugitive Dust (Paved and Unpaved Roads) – Emissions of PM_{10} and $PM_{2.5}$ in the form of fugitive dust from paved and unpaved roads were estimated for the boroughs of Anchorage, Fairbanks, and Juneau. Calendar year 2002 roadway miles of unpaved roads, along with the associated vehicle miles traveled (VMT), were estimated from local data and discussions with state and local agency staff. Paved roadway VMT was estimated by subtracting the unpaved road VMT from the total borough VMT.[44][45] Calculations for both paved and unpaved road emissions were based on current procedures *(circa 2003)* in EPA's AP-42 report.[46] A discussion of the procedures, data sources, and inventory results follows separately for unpaved and paved roads.

AP-42 Emission Factor Equations – The equation in AP-42 for estimating particulate emissions from "dry" (no precipitation) unpaved publicly accessible roads dominated by light-duty vehicles is given as follows.

$$E = \frac{k(s/12)(S/30)^{0.5}}{(M/0.5)^{0.2}} - C \qquad \textbf{(6)}$$

Where:

E is the dry emission factor in lb/VMT;
k is a particle size empirical constant (1.8 for PM_{10}, 0.27 for $PM_{2.5}$);
s is the surface material % silt content;
M is the surface soil % moisture content;
S is the mean vehicle speed in miles per hour (mph); and
C is the 1980's motor vehicle particulate emission factor in lb/VMT (0.00047 for PM_{10}, 0.00036 for $PM_{2.5}$).[47]

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[44] Discussions with DOT&PF confirmed that the total VMT is the best estimate of VMT from all road types—paved and unpaved—in the Borough.
[45] Communication with Jeff Roach, Transportation Planner, Fairbanks Office, Department of Transportation and Public Facilities (DOT&PF), June 2005.
[46] "AP-42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources," Section 13.2.1-13.2.2 Paved and Unpaved Roads, Environmental Protection Agency, December 2003.
[47] The previous versions of the unpaved and paved road emission factor equations in AP-42 included exhaust, brake-wear and tire-wear emissions from vehicles in the 1980 calendar year fleet. These emissions are now estimated as part of the on-road mobile emissions and have decreased since 1980 due to lower new vehicle emission standards

Alaska-specific factors were used in Equation (6) as much as possible for estimating unpaved road emissions for the three boroughs. For the surface material silt content, 15% was used, which was the average from samples collected on unpaved streets in the Mendenhall Valley for a 1988 PM_{10} inventory prepared by Engineering Science[48] for EPA. The soil moisture content used in this analysis was 1.1% – the average found for measured unpaved roads in EPA Region 10.[49] Based on discussions with the City of Fairbanks and the City and Borough of Juneau, the mean vehicle speed on unpaved roadways was estimated at 25 mph. Unfortunately, no estimate for mean vehicle speed on unpaved roadways was available from Anchorage; therefore, the 25 mph estimate was used for all three boroughs.

The fugitive dust emissions estimated using Equation (6) reflect the average "dry" conditions of unpaved roads in a given area. That is, the natural mitigating effect of precipitation would need to be considered as any increase in moisture reduces the level of emissions from the roads. In order to account for the natural precipitation that controls fugitive dust in the local areas, the dry emission factor E is adjusted using the following equation from AP-42:

$$E_{unpaved} = E\left[(N - p) / N\right] \quad \textbf{(7)}$$

Where:

$E_{unpaved}$ is the final unpaved roads emission factor adjusted for natural mitigation in lb/VMT;
N is the total number of days in the study period (182 for summer and 183 for winter); and
p is the number of days in the study period with at least 0.01 inch of precipitation (precipitation days).

Locality-specific precipitation days for Anchorage, Fairbanks, and Juneau were derived from the monthly averages available from the Western Regional Climate Center (WRCC).[50] The WRCC keeps records for days per month with measurable precipitation (at least 0.01 inch) for the three boroughs and has monthly averages over the last 50 years. Table 5.6-45 shows the average seasonal WRCC precipitation data for Anchorage, Fairbanks, and Juneau.

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and new fuel specifications. Therefore, this was subtracted from the AP-42 paved and unpaved road fugitive dust emissions in order to prevent double counting of emissions.

[48] "PM_{10} Emission Inventories for the Mendenhall Valley and Eagle River Areas," prepared for the U.S. Environmental Protection Agency by Engineering Science, EPA Contract Co. 68-02-4398, Work Assignment 7, February 1988.

[49] C. Cowherd, Jr., et al., "Improved Activity Levels for National Emission Inventories of Fugitive Dust from Paved and Unpaved Roads," Presented at the 11th International Emission Inventory Conference, Atlanta, Georgia, April 2002.

[50] Average Number of Days with Measurable Precipitation for Alaska, Historical Climate Information, Western Regional Climate Center website, http://www.wrcc.dri.edu/htmlfiles/ak/ak.01.html, Updated to 2004.

Table 5.6-45 Days/Season with at Least 0.01 Inch of Precipitation		
County/Borough	Winter	Summer
Anchorage	54 (stays on ground)	61
Fairbanks	50 (stays on ground)	57
Juneau	117	106

After discussions with ADEC staff and a review of the average winter temperatures in the area, it was concluded that the precipitation occurring in Fairbanks and Anchorage during the winter keeps fugitive dust under control during the entire season. This effect is not seen in Juneau, however, where the temperate climate prevents the snow and ice to remain covering the roadways during the season.

Similar to unpaved roads, fugitive emissions from paved roads take into account road surface properties, traffic conditions, and climate for natural mitigation. The AP-42 equation which considers all these factors for estimating paved road emissions is:

$$E_{paved} = \left[k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C \right] \left[(4N - p)/4N \right] \qquad \textbf{(8)}$$

Where:

E_{paved} is the final unpaved roads emission factor adjusted for natural mitigation in lb/VMT;
k is a particle size empirical constant (0.016 for PM10 and 0.004 for $PM_{2.5}$);
sL is the road surface silt loading in g/m^2;
W is the average weight of vehicle traveling the road in tons;
C is the 1980s motor vehicle particulate emission factor in lb/VMT (0.00047 for PM_{10}, 0.00036 for $PM_{2.5}$);
N is the total number of days in the study period (182 for summer and 183 for winter); and
p is the number of days in the study period with at least 0.01 inch of precipitation.

Equation (8) is analogous to the combination of Equations (6) and (7) for fugitive dust from unpaved roads. However, Equation (8) includes a factor of "4" in the natural precipitation mitigation effects because paved roads dry quicker than unpaved roads after precipitation events.

The road surface silt loading for the paved roads in the three boroughs were based on paved road samples collected from different roadway facility types in Anchorage between March and

August of 1996.[51] These silt loading values as applied to the summer and winter seasons are shown in Table 5.6-46. The average weight of the vehicle traveling on the roads was set to 2.0 tons, which was used for the Mendenhall Valley paved roads in the 1988 Engineering Science report for EPA.[52] The days per season with measurable precipitation (at least 0.01 inch) were those shown earlier in Table 5.6-45.

Table 5.6-46
Seasonal Paved Roads Silt Loading (g/m^2) by Facility Type

Facility	Winter	Summer
Interstate/Major Arterial	2.6	20.4
Minor Arterial	1.1	6.7
Collector	2.9	9.4
Local Roads	4.7	18.4

Both the paved and unpaved road emissions are expressed on a per VMT basis (lb/VMT). Therefore, VMT levels for the paved and unpaved roadways in the three boroughs needed to be estimated as explained in the following paragraphs.

2002 Paved Roadway Activity and Data Sources - The total daily VMT for a road is calculated as the product of the annual average daily traffic (AADT) and the roadway length in miles (VMT = AADT × Road Length). The traffic data necessary to estimate the VMT from the paved and unpaved roads for the three boroughs vary in scope and detail, and a variety of methods were used to estimate VMT for the paved and unpaved roads. First, the total daily VMT for all roads were estimated for each borough. The VMT and associated emissions for unpaved roads was then estimated using the unpaved road mileage and estimated AADT. Lastly, the VMT for unpaved roads was subtracted from the total borough VMT, and the remaining VMT was used to estimate emissions from the paved roads.

The average calendar year 2002 daily VMT data for the boroughs of Anchorage and Fairbanks were obtained from the Municipality of Anchorage (MOA)[53] and the Alaska Department of Transportation and Public Facilities (DOT&PF)[54], respectively. The total daily VMT for Anchorage was developed by combining the estimates of travel for the urban nonattainment area, Eagle River, and Chugiak. In addition, VMT estimates for Girdwood and the rest of the

[51] "Identification, Quantification, and Control of PM-10 Sources in Anchorage," prepared by Midwest Research Institute for the Municipality of Anchorage, April 15, 1999.
[52] The paved road silt loadings used in this analysis are different from those used in the 1988 Engineering Science report prepared for the Mendenhall Valley, which applied national average default values in AP-42. Since the silt loading measurements taken in Anchorage represent locally derived, state-specific measurements, these Anchorage silt loadings were used for all three boroughs.
[53] Communication with Steve Morris, Environmental Quality Program Supervisor, Environmental Services Division, Municipality of Anchorage Department of Health & Human Services, May-June 2005.
[54] Communication with Margaret Carpenter, Planner, Fairbanks Office, Department of Transportation and Public Facilities (DOT&PF), May 2005.

Turnagain Arm areas and Eklutna were developed using data and traffic activity assumptions from MOA. Estimated 2002 travel and average speed by facility type in Fairbanks were obtained from ADOT&PF for the entire borough. For Juneau, the 2002 VMT and average speed estimates by facility type were developed by extrapolating average daily travel and speed data obtained from ADOT&PF-monitored roadways to the rest of the network and adjusting 1999 and 2004 VMT estimates to 2002 levels using yearly population data for the Borough.

Table 5.6-47 shows the 2002 total daily VMT for each borough. Seasonal VMT adjustments were available for Fairbanks to estimate winter VMT (average factor of 0.92). However, no seasonal factors were available for Anchorage and Juneau, and the average annual daily VMT was used for both the summer and winter seasons for these two boroughs as a conservative approach.[55]

Table 5.6-47
2002 Total Daily VMT by Borough

County/Borough	VMT
Anchorage	3,286,323
Fairbanks[a]	1,869,833
Juneau	742,815

[a] Winter VMT are about 92% lower.

Unpaved Roadway VMT - The travel on unpaved roads in each borough was estimated using a variety of data sources. Table 5.6-48 summarizes the data sources, unpaved roadway miles and VMT estimated for each borough. For Anchorage and Fairbanks, unpaved road VMT was collected for the summer only because winter precipitation and the presence of snow and ice completely mitigates fugitive dust from all roads during the winter season. The more temperate climate in Juneau results in fugitive dust emissions year-round. The nature of the data obtained and the means by which the VMT were estimated are summarized separately by borough below.

Anchorage - MOA staff were contacted to obtain unpaved roadway data for 2002. Several sources of information were provided. First, the 1999 Midwest Research Institute (MRI) PM_{10} Inventory report[56,57] contained the best estimate of the 2002 roadway data and inventory of unpaved road emissions within the nonattainment area. In addition, MOA provided a 1987 conformity analysis for the Eagle River PM_{10} nonattainment area, and a 2002 estimate of unpaved road VMT in the area was derived from interpolating between the projected 2000 and 2003 estimate included in the analysis.

55 Communication with Steve Morris at MOA indicated that their winter on-road mobile inventory analyses involve using the annual average VMT as a conservative, worst-case scenario.

56 "Identification, Quantification, and Control of PM-10 Sources in Anchorage," prepared by Midwest Research Institute for the Municipality of Anchorage, April 15, 1999.

57 In order to apply the PM_{10} estimates to the seasons defined in this analysis, the emissions for October through November were estimated as the winter average, while the emissions for March through April were estimated as the summer average.

Table 5.6-48 2002 Unpaved Road VMT and Data Sources				
County/ Borough	Data Source	Facility Type	Unpaved Road Miles	2002 VMT
Anchorage	1999 PM10 Inventory	Local	93.0	45,000
	Eagle River PM10 Conformity	Local	0.21	82
	Eagle River/Chugiak Road Inventory	Local	25.3	9,861
	MOA Girdwood/Turnagain Arm/ Eklutna Estimate	Local	n/a[a]	1,068
	ALL TOTAL		118.5+	56,011
Fairbanks	DOT&PF	Minor Arterial	31.7	2,360
		Minor Collector	26.6	6,594
		Local	293.1	25,556
	City of Fairbanks	Minor Arterial	2.4	179
		Local	4.9	424
	City of North Pole	Local	0.4	36
	FNSB	Major Collector	20.1	20,054
		Minor Collector	240.6	59,681
		Local	140.4	12,213
	ALL TOTAL		760.1	127,097
Juneau	DOT&PF	Local	2.4	424
	CBJ	Local	12.4	2,178
	ALL TOTAL		14.9	2,601

[a] VMT was estimated directly without generating estimated miles.

For the Eagle River and Chugiak areas that are outside the PM_{10} area, MOA provided a copy of the local road inventory, which lists the roads, road miles, and surface conditions. VMT for these roads were estimated by using an AADT of 390 vehicles per day derived from the unpaved roadways in the Eagle River PM_{10} conformity analysis. Lastly, MOA provided a means of estimating the unpaved road VMT from Girdwood and the rest of the Turnagain Arm and Eklutna using 2000 Census Bureau populations for these smaller communities and the entire borough.[58] The resulting unpaved roadway VMT estimated for the entire borough totaled 56,011 miles per day, all of which occur on gravel roads.[59]

Fairbanks – The 2004 pavement data were obtained from ADOT&PF, which included a listing of the roadways in the borough, along with “paved” or “unpaved” designations.[60] As 2002 data were not available, ADOT&PF staff indicated that the 2004 pavement data are a good estimate of the miles of unpaved roads in the borough and that minimal paving has occurred between

[58] Per discussion with Steve Morris of MOA, the following equation was used to estimate unpaved road VMT for Girdwood/Turnagain Arm/Eklutna (GTE): unpaved GTE VMT = (rest of borough unpaved average daily VMT)*(GTE population/borough population)*2.
[59] Per Steve Morris of MOA, all unpaved roadways are gravel.
[60] Communication with Kathleen Ramage, Road Network Service Manager, Division of Program Development, Alaska Department of Transportation and Public Facilities (DOT&PF), May 2005.

2002 and 2004. The listing included all DOT&PF-maintained roads in the borough as well as unmaintained public roads and some roads maintained by other agencies (cities and the borough). Discussions with ADOT&PF revealed that the pavement road data are up to date for the ADOT&PF-maintained roadways, but that the information on roads maintained by other agencies may be outdated.

In order to supplement the ADOT&PF pavement data, the City of Fairbanks,[61] City of North Pole,[62] and the Fairbanks North Star Borough (FNSB)[63] were contacted for their 2002 unpaved roadway data. The City of Fairbanks provided 2002 roadway data, while the City of North Pole and FNSB provided current 2004/2005 roadway conditions data. However, both the City of North Pole and FNSB indicated that there have been minimal changes in the miles of unpaved roads between 2002 and 2004/2005 and that the current data are the best estimates for 2002 unpaved roadway miles available. The street names and descriptions in the data from the cities and the borough were compared to the streets in the ADOT&PF pavement data, and duplicate roadways were removed from the ADOT&PF roadway mileage in order to make sure no overlap or double counting occurs. Because ADOT&PF indicated that its information on roads maintained by other agencies might be outdated, more credence was given to the city and borough roadway data on whether a street is "paved" or "unpaved" when the information conflicted with that from ADOT&PF. A total of about 760 miles of unpaved roadways was found for Fairbanks, all of which consists of gravel or aggregate roads.[64]

VMT data were not readily available for remaining roads in the borough. Limited VMT and annual AADT information were obtained for some of the Fairbanks roads in the 2004 pavement data from the 2003 annual average daily traffic records available from ADOT&PF.[65] Using the 2003 traffic data, estimates for AADT for 100 miles of DOT-managed unpaved local roads, minor arterials, and minor collectors were found. For these, the 2003 AADT data were adjusted to 2002 levels using a 3.4% annual VMT growth rate, which is the average VMT growth rate for the entire borough for the last three years obtained from ADOT&PF. The estimated 2002 AADT levels were then used for the unpaved local roads, minor arterials, and minor collectors with no AADT data. However, in addition to these three roadway facilities, the borough had unpaved major collectors that did not have AADT data from ADOT&PF. In order to estimate the VMT for unpaved major collectors, an annual AADT level of 1,000 vehicles was estimated by FNSB staff.[66] The AADT levels by facility type used to estimate VMT for the unpaved roadways in Fairbanks are shown in Table 5.6-49. Application of these AADT levels resulted in a total unpaved roadway VMT of 127,097 miles per day for the borough.

[61] Communication with David Jacoby and David Weaver, City of Fairbanks, June 2005.
[62] Communication with Jim Remitz, City Engineer, City of North Pole, May 2005.
[63] Communication with Trent Mackey, Fairbanks North Star Borough, May-June 2005.
[64] Due to climate and other roadway conditions in Fairbanks, all unpaved roads need to have at least gravel or aggregate, per discussions with FNSB, City of Fairbanks, and City of North Pole.
[65] 2003 Northern Region Traffic Volume Data Files, Alaska Highway Data, Alaska Department of Transportation and Public Facilities website, *http://www.dot.state.ak.us/stwdplng/highwaydata/traffic.shtml#traffic_data*, July 2004.
[66] Communication with Trent Mackey, Fairbanks North Star Borough, May-June 2005.

Table 5.6-49 2002 AADT by Facility for Unpaved Roads in Fairbanks		
Unpaved Facility Type	AADT	Source
Major Collectors	1,000	FNSB
Minor Collectors	248	DOT&PF
Minor Arterials	74	DOT&PF
Local Roads	87	DOT&PF

Juneau – Because 2002 unpaved roadway data were not available, the 2004 pavement data from ADOT&PF[67] were used to estimate the miles of unpaved roads in the borough. In addition to this, ADOT&PF provided additional data on roadways that were not paved as of 2002 that were not included in the 2004 pavement data.[68] As with the Fairbanks data, ADOT&PF indicated that the pavement road data are up to date for the ADOT&PF-maintained roadways, but that the information on roads maintained by other agencies may be outdated. Consequently, the City and Borough of Juneau (CBJ) was contacted for 2002 unpaved road data for roadways under their management,[69] and the CBJ data were compared with the ADOT&PF data to eliminate duplicates and double counting. More confidence was given to the CBJ data when conflicting information existed on paving status for some roadways between the ADOT&PF and CBJ data sets.

A total of about 14.9 miles of unpaved roadways, all local roads, was found for Juneau. Of this, about 11.8 miles are gravel or aggregate roads, 2.75 miles are undeveloped dirt roads, and 0.32 miles are overlaid with recycled asphalt pavement (RAP).[70] As with Fairbanks, VMT and AADT data were limited. Consequently, the only unpaved local road AADT available for Juneau came from the 1988 PM_{10} emissions inventory prepared for the Mendenhall Valley by Engineering Science.[48] In the report, an AADT of 171 was obtained from counts performed on 12 local streets. This estimate was adjusted to 2002 levels using the borough population growth between 1988 and 2002. The 1988 population was estimated by Engineering Science in the PM_{10} inventory report, while the 2002 borough population was derived by selecting the mid-point between the 2000 Census Bureau estimate and 2004 population data available from the Alaska Department of Labor and Workforce Development (ADLWD).[71] The resulting adjusted AADT applied to all unpaved local roadways in Juneau is 175 vehicles per day. This, combined with the total miles of unpaved roads in the borough, resulted in a total unpaved road daily VMT of 2,601 in Juneau.

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[67] Communication with Kathleen Ramage, Road Network Service Manager, Division of Program Development, Alaska Department of Transportation and Public Facilities (DOT&PF), May 2005.
[68] Communication with David Hawes, Transportation Planner, Southeast Region, Department of Transportation and Public Facilities (DOT&PF), May 2005.
[69] Communication with Mike Scott, Streets Superintendent, City and Borough of Juneau, June 2005.
[70] Recycled asphalt pavement (RAP) is reprocessed pavement material containing asphalt and aggregates that, when processed properly, consists of high-quality, well-graded aggregates coated by asphalt cement. RAP provides some, but not complete, control of fugitive dust emissions from unpaved roads.
[71] The 1988 total borough population was 29,946, and the 2004 population was 30,966, which results in a 2002 population of 30,584.

Paved Roadway VMT – The resulting paved roadway VMT by borough after the unpaved roadway VMT were subtracted from the total VMT are shown in Table 5.6-47 by facility.

Table 5.6-50
2002 Paved Road VMT by Facility and Borough

County/Borough	Facility	2002 VMT
Anchorage	Freeway/Expressway	501,789
	Major/Principal Arterial	1,848,979
	Minor Arterial	332,284
	Collector/Intrazonal	197,141
	Local	350,119
	ALL TOTAL	3,230,312
Fairbanks (winter VMT are about 92% lower)	Freeway/Expressway	221,207
	Major/Principal Arterial	606,665
	Minor Arterial	240,736
	Collector/Intrazonal	581,797
	Local	92,331
	ALL TOTAL	1,742,736
Juneau	Major/Principal Arterial	330,862
	Minor Arterial	101,119
	Collector/Intrazonal	122,311
	Local	185,922
	ALL TOTAL	740,214

2002 Fugitive Dust Emissions - The emission factors for paved roads found using Equation (8) were combined with the paved road VMT estimates for each borough to result in the PM_{10} and $PM_{2.5}$ inventories shown in Table 5.6-48. The annual average emission inventories were estimated by weighting the summer and winter emission levels by the number of days in each season as defined by ADEC—183 for the summer and 182 for the winter. The PM_{10} and $PM_{2.5}$ emissions from paved roads varied only between the boroughs mainly because of the different VMT levels and partly due to the differences in local precipitation mitigation (Juneau has about double the precipitation days per season as Anchorage and Fairbanks). As previously noted, based on discussions with ADEC staff and on the local winter temperatures, it was concluded that the fugitive dust from paved roads during the winter season in Fairbanks and Anchorage is fully mitigated by the amount of precipitation that covers the roadways during the entire season.

Table 5.6-51
2002 Paved Road Seasonal Fugitive Emissions in Tons/Day

County/ Borough	PM_{10} (tpd)			$PM_{2.5}$ (tpd)		
	Winter	Summer	Annual	Winter	Summer	Annual
Anchorage	0.00	52.74	26.44	0.00	12.83	6.43
Fairbanks	0.00	24.74	12.40	0.00	5.99	3.00
Juneau	3.29	10.43	6.87	0.75	2.53	1.64

A summary of the unpaved road PM_{10} and $PM_{2.5}$ emission inventories is shown in Table 5.6-49. As with the paved road inventories, unpaved road annual average emissions were estimated by weighting the summer and winter emission levels by the number of days in each season. For unpaved roads, Equations (6) and (7) were used along with the borough unpaved road VMT in order to estimate fugitive dust emissions for Juneau (year-round) and Fairbanks (summer only). The Anchorage summer PM_{10} emissions for unpaved roads for the urban nonattainment area and the Eagle River PM_{10} area were derived directly from the 1999 MRI inventory report and the Eagle River PM_{10} conformity analysis, respectively. The $PM_{2.5}$ unpaved road emissions for these areas were estimated using a ratio of 0.15 for $PM_{2.5}$ to PM_{10} emissions, which was found to be consistent for all unpaved roadway $PM_{2.5}$ and PM_{10} emissions estimated using the AP-42 equations. The summer emissions from the rest of the MOA (outside the PM_{10} areas) were found using Equations 1 and 2 along with the estimated VMT for the area. As previously noted and as reflected in the paved roads fugitive dust inventory, the effective precipitation during the winter in Fairbanks and Anchorage fully mitigates any fugitive dust from the unpaved roadways there during the winter season. As shown in Table 5.6-52, there is little seasonal difference in the unpaved road emissions for Juneau with emissions being slightly higher in the summer.

Table 5.6-52
2002 Unpaved Road Seasonal Fugitive Emissions in Tons/Day

County/ Borough	PM_{10} (tpd)			$PM_{2.5}$ (tpd)		
	Winter	Summer	Annual	Winter	Summer	Annual
Anchorage	0.00	3.52	1.77	0.00	0.53	0.26
Fairbanks	0.00	39.90	20.00	0.00	5.98	3.00
Juneau	0.50	0.59	0.55	0.07	0.09	0.08

Asphalt Plants – Asphalt production data was supplied by ADEC staff for the Anchorage Fairbanks, and Juneau areas. This information is maintained by ADEC as part of its Minor Source permitting program. The asphalt production totals reported for calendar year 2002 in Juneau and Fairbanks were multiplied by AP-42 emission factors for asphalt production appropriate for the given facility, to give total tons of emissions per season. The winter season total was then divided by 182 days to give tons per day. Note that, unless a combustion source is equipped with a selective catalytic reduction (SCR) unit, ammonia emissions are considered to be negligible. Any ammonia present in the fuel or combustion unit, unless it is added during the post-combustion process, would be completely converted to NO_x at the temperatures under which asphalt production takes place. Calculation details are provided in Appendix C of the study report.

Asphalt Paving – In estimating emissions from this source, the assumption was made that all of the asphalt produced by the asphalt plants listed is used locally, and all within the summer months (i.e., April through September). This is a conservative assumption for two reasons: first, because it is likely that at least a portion of the asphalt produced in the various areas was transported and applied to a roadway outside the boundaries of the Borough or Municipality;

and, second, it is possible that not all the asphalt produced during the year was used for paving the same year.

All particulate emissions from asphalt paving are in the form of condensable hydrocarbons (i.e., TOG or VOC emission factors), as discussed in AP-42 section 4.5 for Asphalt Paving Operations. The specific VOC emission factor used (i.e., 0.04 pounds per ton of asphalt applied), is the California Air Resources Board (CARB) recommended emission factor[72] for this emission source.

Gasoline Distribution – This category refers to organic gas emissions resulting from the storage and transfer operations at gasoline dispensing facilities. Emissions in this category can be divided into three types:

- Spillage;
- Vapors displaced through vehicle refueling; and
- Working and breathing losses from underground tanks.

EPA's on-road (MOBILE) and off-road (NONROAD) emission models calculate emission totals associated with the first two types listed above, and are included in the totals listed in the area source summary tables. Emissions from the third emission type listed above were calculated using proprietary gasoline throughput data obtained from local producers. For this reason, the specific calculation methodology for this source has been reported to ADEC staff, but is not available to the general public.

Surface Coatings – This source, which was included in the 1999 Air Toxics Inventory, is a source of VOC emissions only. Repeated attempts to locate area-specific coating usage were unsuccessful, and we have therefore used the same methodology described in the earlier inventory. Calendar year 2002 national paint usage data were obtained from U.S. Census Bureau's Manufacturing, Mining, and Construction Statistics.[73] Paint usage was listed according to three general categories: architectural coatings, special-purpose coatings, and miscellaneous allied paint products. According to a representative of the National Paint and Coatings Association,[74] there are no paint manufacturing facilities in Alaska, and likely very little equipment manufacturing in the state because the cold wintertime temperatures make year-around production problematic. Therefore, with the exception of marine-related coatings, the total gallons listed under "Product finishes for original equipment manufacturers (OEM)" were not included. Representative VOC emission factors were obtained from CARB's Index of Area Source Methodologies, section 6.3 on Architectural Coatings.[75] All surface coatings are assumed to have been applied during the summer months, as Alaska winter weather conditions are not amenable to painting operations.

[72] This emission factor is referenced in a document found on the CARB website at *http://www.arb.ca.gov/ei/areasrc/draftmeth/asphcompar.pdf*.
[73] This report is available on the U.S. Census website at *http://www.census.gov/cir/ www/325/mq325f.html*
[74] Personal communication between Allen Irish of the National Paint and Coatings Association and Lori Williams of Sierra Research.
[75] This methodology is posted on the CARB website at *http://www.arb.ca.gov/ ei/areasrc/fullpdf/FULL6-3.pdf*

Wildfires – Total emissions from wildfires in Alaska are included in the Western Regional Air Partnership's (WRAP) recently completed 2002 air emission inventory for fire. That database shows that there were eleven FNSB-based wildfires in 2002, and one in Juneau. All wildfire activity was confined only to the summer season.

Open Burning (Firefighter Training) – Local staff in Anchorage and Fairbanks provided activity data for this emission source. In Anchorage, firefighter training was estimated to occur 28 times per year and to utilize 200 gallons of fuel per exercise, for a total of 5,600 total gallons burned during the summer months. All fuel burned was assumed to be Diesel. According to Fairbanks sources, such exercises occur once per month during the April through September time period, for a total of 1,200 gallons burned per year. In the absence of any more accurate emission factors, the methodology used in the 1999 Air Toxics report was used to calculate emissions from this source; AP-42 emission factors for residential furnaces were applied to the activity data discussed above. In the absence of any activity data for Juneau, the Anchorage emissions for this source were extrapolated to Juneau based on human population.

Structural Fires – The number of structural fires in Fairbanks was assumed to be the same as that used in the 1990 Fairbanks CO Inventory—one per inventoried day. Emission factors developed by the California Air Resources Board[76] (CARB) were applied to this activity estimate to generate the emission totals.

According to ADEC staff, there were a total of 363 structural fires in the Anchorage area in 1983. ADEC staff estimate this figure increased to approximately 400 fires per year in 1999, and the same activity rate was assumed for 2002. Applying this activity rate to the CARB emission factors discussed above gives what is likely a disproportionately high level of emissions. This is because the emission factors include assumptions regarding combustible contents per square foot, average floor space, and percent of structural loss, which may not correspond to the structures burned in the Anchorage fires. However, in the absence of any other information, we have calculated the emissions from this source based on the estimate of 400 structural fires, distributed evenly over the calendar year.

For Juneau, the total number of incidences for structural fires in 2002 was obtained from the Juneau Fire Marshal.[77] A total of 11 structural fires were recorded in 2002 for the entire borough; however, the Fire Marshal estimated that about 65% of the fires occurred in the wintertime and 35% occurred during the summer. Emission factors developed by the California Air Resources Board[78] (CARB) were applied to the seasonal activity estimates to generate the emission totals.

Projection of 2002 Base Emissions to 2005 – The preceding paragraphs described the local data sources and methods used to estimate calendar year 2002 seasonal and annual emissions for each

[76] "Area Source Methodologies Manual," California Air Resources Board, June 1994.
[77] Communication with Richard Etheridge, Fire Marshal, Capital City Fire/Rescue Fire Department, Juneau, Alaska, August 2005.
[78] "Area Source Methodologies Manual," California Air Resources Board, March 1999.

area source category. 2002 base emissions were then projected forward to 2005 using a combination of VMT and population forecasts as described below:

- *Fugitive Dust* – Projected 2005 paved and unpaved road dust emissions were calculated based on forecasted VMT growth from 2002 to 2005. For Fairbanks, this growth estimate was developed from ADOT&PF forecasts as described in the Big 3 study report. Annual VMT growth from 2002-2005 was 0.2% for paved roads and -2.1% for unpaved roads, the latter decrease reflecting paving some of what were unpaved roads in 2002.

- *All Other Area Sources* – Projected 2005 emissions for all other area source categories was based on population growth data and projections for the Fairbanks Borough compiled by the Alaska Department of Labor and Workforce Development. The ADLWD estimated an annual 1.1% population growth rate for the borough from 2002 to 2005.

Using these growth estimates, the 2002 base emissions were projected to calendar year 2005 under the Big 3 study and served as the primary basis for the Other Area Source sector (excluding space heating) of the SIP inventory. Table 5.6-53 and Table 5.6-54 present the resulting Other Area source annual and winter average daily emissions, respectively by source category/SCC for 2005.

Table 5.6-53
2005 Annual Big 3-Based Fairbanks Other Area Source Emissions (tons/day)

Source Category	SCC	Annual Average Emissions (tons/day)						
		VOC	CO	NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$
Fugitive Paved Road Dust	2294000000	0.00	0.00	0.00	0.00	0.00	11.63	2.82
Fugitive Unpaved Road Dust	2296000000	0.00	0.00	0.00	0.00	0.00	18.75	2.81
Asphalt Paving/Roofing Materials	2306010000	0.00	0.01	0.00	0.00	0.00	0.11	0.01
Architectural Coatings	2401001000	0.66	0.00	0.00	0.00	0.00	0.00	0.00
Commercial Asphalt Application	2461020000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline Service Stations, Stage 2: Spillage	2501060102	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline Service Stations, Stage 2: Displacement Loss/Controlled	2501060103	0.41	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum and Petroleum Product Storage, All Storage Types: Working Loss, Gasoline	2501000120	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum and Petroleum Product Storage, All Storage Types: Breathing Loss, Gasoline	2501995120	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Forest Wildfires	2810001000	9.72	206.60	4.43	1.22	0.93	20.09	17.23
Structure Fires	2810030000	0.01	0.11	0.00	0.00	0.00	0.01	0.00
Firefighting Training	2810035000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005 Totals		**10.89**	**206.72**	**4.44**	**1.22**	**0.93**	**50.58**	**22.86**

Table 5.6-54
2005 Winter Big 3-Based Fairbanks Other Area Source Emissions (tons/day)

Source Category	SCC	Winter Average Daily Emissions (tons/day)						
		VOC	CO	NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$
Fugitive Paved Road Dust	2294000000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fugitive Unpaved Road Dust	2296000000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asphalt Paving/Roofing Materials	2306010000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Architectural Coatings	2401001000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial Asphalt Application	2461020000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline Service Stations, Stage 2: Spillage	2501060102	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline Service Stations, Stage 2: Displacement Loss/Controlled	2501060103	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum and Petroleum Product Storage, All Storage Types: Working Loss, Gasoline	2501000120	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum and Petroleum Product Storage, All Storage Types: Breathing Loss, Gasoline	2501995120	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Forest Wildfires	2810001000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Structure Fires	2810030000	0.01	0.11	0.00	0.00	0.00	0.01	0.00
Firefighting Training	2810035000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005 Totals		**0.45**	**0.11**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**

As noted earlier, there are significant seasonal variations for most of the key source categories within the Other Area Source sector. In comparing total sector emissions at the bottom of Table 5.6-53 and Table 5.6-54, winter emissions are significantly lower that annual daily averages, largely due to the fact that activity for many of these source categories is near zero during winter.

Incorporation of Commercial Cooking Emissions

At the time an initial Fairbanks gridded inventory was developed under a 2009 EPA Office of Research and Development (ORD) study, ORD developed a series of sector- and SCC-level comparisons of emissions between those developed for Fairbanks from the Big 3 study within 2005 National Emissions Inventory (NEI) estimates for the borough. From this comparison, it was determined that emissions from commercial cooking (charbroiling and frying) had not been included in the Big 3 estimates.

Commercial cooking emission estimates were developed and incorporated into the SIP inventory using 2008 NEI-based estimates for Fairbanks. Table 5.6-55 shows these 2008 NEI estimates on an annual basis.

Table 5.6-55 2008 Annual NEI-Based Fairbanks Commercial Cooking Emissions (tons/year)								
		Annual Emissions (tons/year)						
Source Category	SCC	VOC	CO	NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$
Commercial Cooking - Charbroiling /Conveyorized Charbroiling	2302002200	0.6	2.1	0.0	0.0	0.0	2.4	2.4
Commercial Cooking - Charbroiling /Under-fired Charbroiling	2302003000	2.0	6.6	0.0	0.0	0.0	17.3	16.7
Commercial Cooking - Frying /Clamshell Griddle Frying	2302010000	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Commercial Cooking - Frying /Deep Fat Fying	2302003100	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Commercial Cooking - Frying /Flat Griddle Frying	2302003200	0.3	0.6	0.0	0.0	0.0	5.1	3.8
Commercial Cooking Totals		**3.5**	**9.3**	**0.0**	**0.0**	**0.0**	**25.1**	**23.2**

Unlike many of the other categories within the Other Area Sources sector, commercial cooking emissions were assumed to be constant over the entire year with no seasonal variation.

2008 Baseline and Projected Baselines

Emissions for other area sources for the 2008 baseline and projected baseline inventories to 2019 were developed based on simple borough-wide growth rates developed from the ADLWD and FNSB as follows.

First, 2008 baseline emissions were projected from the 2005 Big 3 estimates using an annualized growth rate of 0.87% (i.e., 1.026 growth multiplier) from 2005 to 2008 developed from the ADLWD forecasts for Fairbanks. Next, projected baseline emissions in 2015 and 2019 were estimated using recently developed post-2010 forecasts for Fairbanks developed by FNSB[79] based on the 2010 U.S. Census and local demographic projections. The long-term forecasted population and household growth after 2010 was forecasted by FNSB at an annualized 1.0% rate averaged across the entire borough, resulting on growth multipliers of 1.062, 1.072 and 1.116 for household and population growth from 2008 to 2015 and 2019, respectively.

Given the relative magnitude of the Other Area Source sector within the entire SIP inventory, these simple, area- and source category-wide population-based growth factors were used to estimate 2008 baseline and projected baseline emissions for sources within the sector. Table 5.6-56 presents summaries of total Other Area Source annual emissions for the 2008 baseline and 2015 and 2019 projected baseline inventories and shows the effects of these growth assumptions.

[79] Email from and follow-up communication with Janet Davison, Fairbanks North Star Borough, July 11, 2012.

Table 5.6-56
Baseline and Projected Baseline Other Area Source Annual Emissions (tons/year)

Calendar Year	Annual Emissions (tons/year)						
	VOC	CO	NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$
2008	11.19	212.21	4.56	1.25	0.95	51.99	23.53
2015	12.00	227.52	4.88	1.34	1.02	55.74	25.23
2019	12.48	236.76	5.08	1.39	1.06	58.01	26.25

ON-ROAD MOBILE SOURCES

This section of the Emissions Inventory Technical Appendix describes the data/sources, methods and tools/workflow used to estimate on-road vehicle emissions across the Fairbanks SIP modeling domain. EPA's MOVES2010a vehicle emissions model 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 SMOKE-ready input structures for use in preparation of gridded, episodic on-road mobile source emissions.

The sequence of steps in generating gridded episodic on-road mobile emissions using the SMOKE-MOVES Tool[80] consists of: 1) MOVES model processing; 2) meteorological data pre-processing; and 3) SMOKE model processing. This process does not create emission estimates (e.g., in tons/day) as is the case with other sectors of the inventory, but instead emission lookup tables are produced which are used by SMOKE to create photochemical model-ready emission fields. Local inputs were used where available when configuring each of the tools used in the steps of this process. The MOVES input data, resulting look-up tables and final processed emissions fields were developed to reflect episode specific conditions in the Fairbanks region during the spans of the two modeling episodes examined in the SIP's attainment analysis:

- Episode 1 - January 23rd – February 12th, 2008; and
- Episode 2 - November 2nd – November 17th, 2008.

The first sub-section discusses MOVES model processing, documenting assembly of model input data. It also describes the meteorological data pre-processing and emission rate processing performed using SMOKE-MOVES sources. The next sub-section explains the importing and model execution workflows used to generate vehicle emission rates processed through SMOKE-MOVES, including generation of lookup tables and processing performed within SMOKE The final sub-section presents summaries of 2008 on-road episodic emissions by SCC code.

DEVELOPMENT OF MOVES INPUTS

Following EPA guidance for use of MOVES in SIP inventory applications, local data were assembled and analyzed to supply regional vehicle fleet and travel activity inputs to the model. Prior to detailed explanations of how the data inputs were developed, the key sources of local data are summarized below.

Key Data Sources - For the 2008 base year, MOVES inputs were based primarily on data gathered as part of the conformity analysis for the Fairbanks Metropolitan Area Transportation System (FMATS) 2012-2015 Transportation Improvement Program (TIP)[81]. FMATS is the

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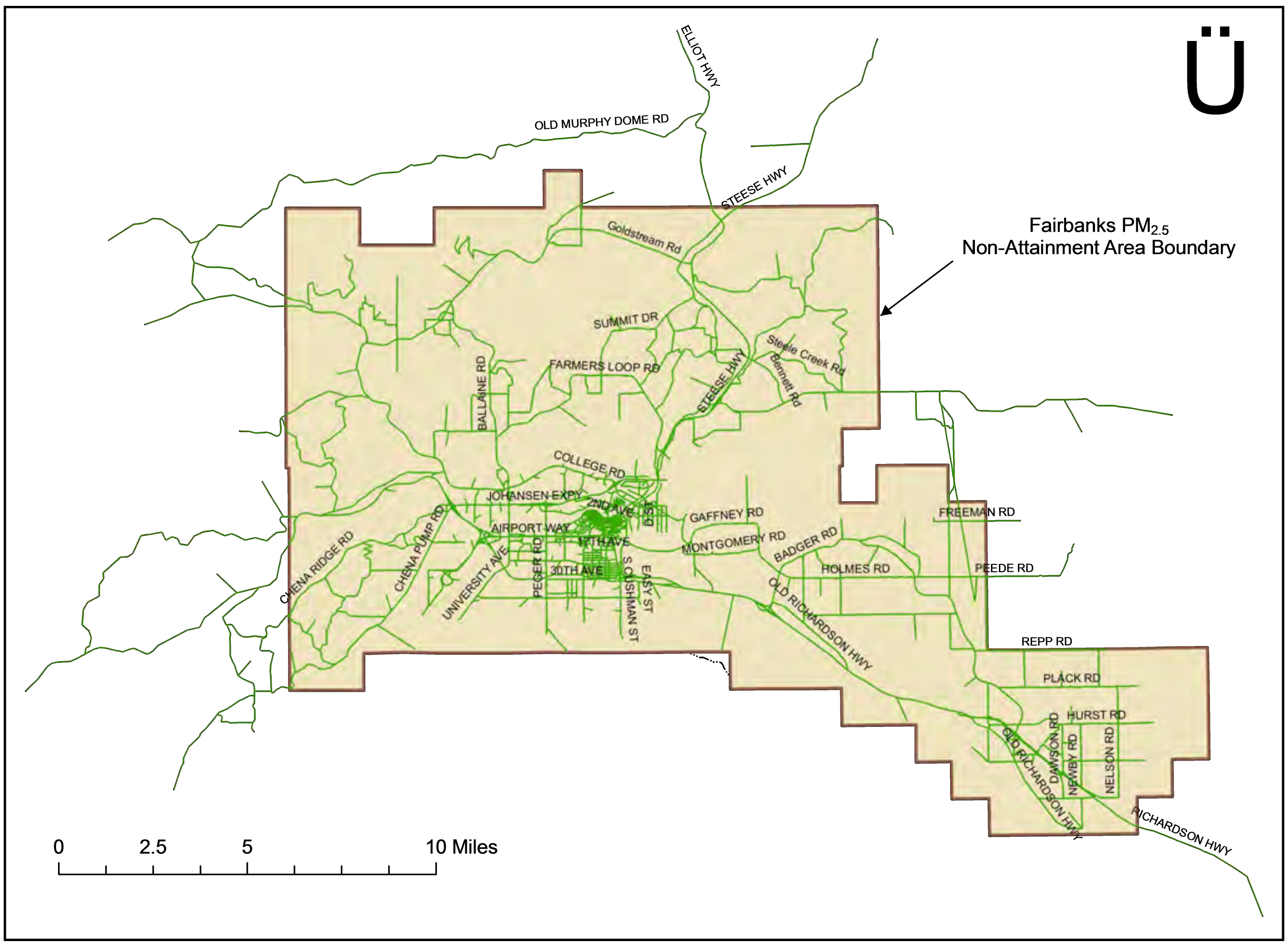
[80] B. Baek, A. DenBleyker, "User's Guide for the SMOKE-MOVES Integration Tool", prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, July 14, 2010. http://www.cmascenter.org/smoke/documentation/smoke_moves_tool/SMOKE-MOVES_Tool_Users_Guide.pdf

[81] T. Carlson, R. Dulla, "Draft Conformity Analysis for Federally Approved 2012-2015 FMATS Transportation Improvement Program (TIP), prepared for Fairbanks Metropolitan Area Transportation System, July 18, 2011.

Metropolitan Planning Organization (MPO) for Fairbanks. The timing of the FMATS TIP was such that it was one of the first regional conformity analyses conducted using MOVES. Inputs for that conformity analysis were derived from local transportation modeling efforts, vehicle registration data, and other local data, each of which is discussed separately below.

Regional Travel Demand Modeling - Vehicle activity on the FMATS transportation network was based on the TransCAD travel demand modeling performed for the 2012-2015 TIP. The TransCAD modeling network covers the entire Fairbanks $PM_{2.5}$ Non-Attainment Area (NAA) and its major links extend beyond the nonattainment area boundary as illustrated below in Figure 5.6-34.

Figure 5.6-34
FMATS TransCAD Modeling Network



The TransCAD model was configured using 2010 U.S. Census-based socioeconomic data. TransCAD modeling was performed for a 2010 base year and a projected 2035 horizon year. Projected population and household data relied on Census 2010 projections and a 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.

Attachment B provides further details on the travel demand modeling runs and validation procedures.

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 2010 base year and 2035 forecast year are presented below in Table 5.6-57.

Table 5.6-57
TransCAD Average Daily VMT by Analysis Year, Daily Period and Fleet Category

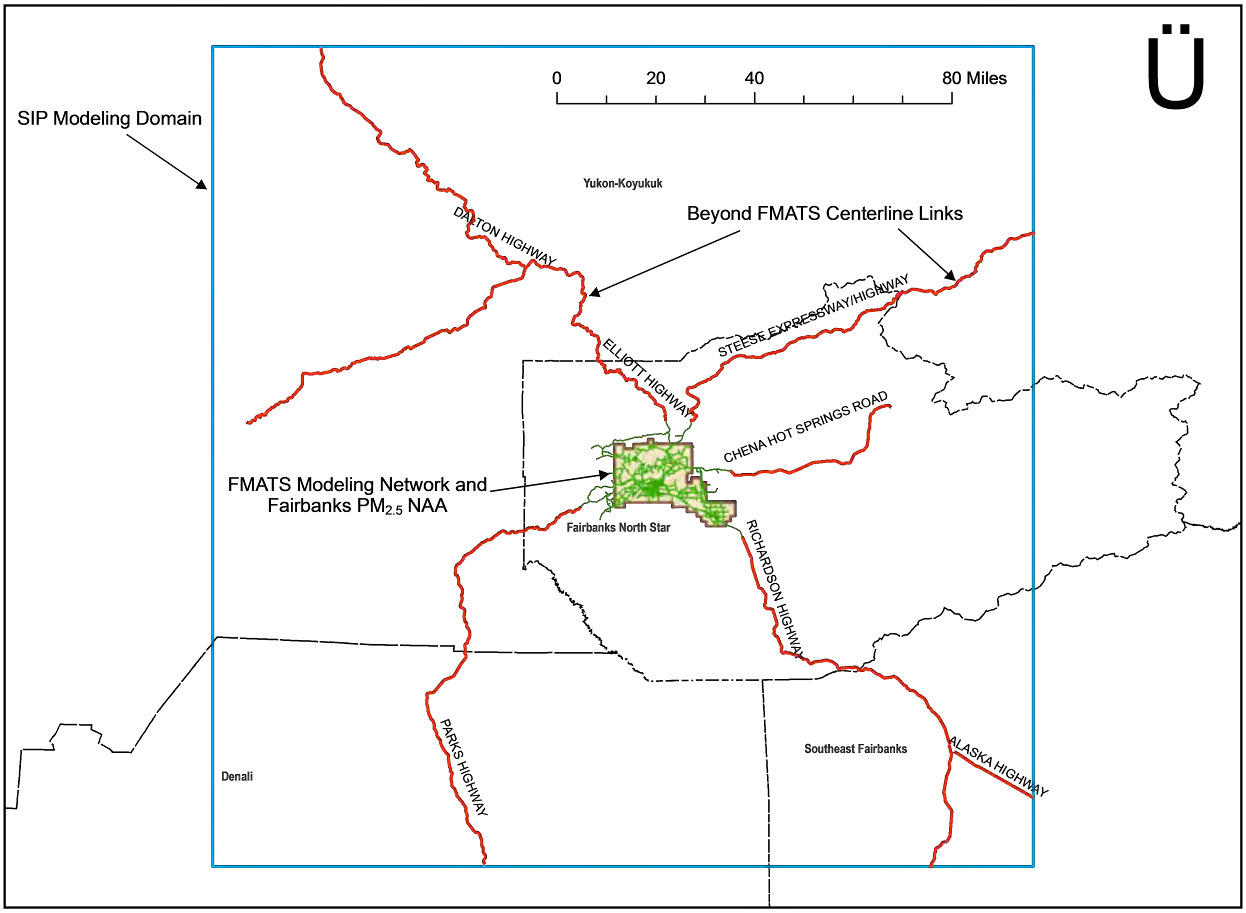
Period / Vehicle Type	Entire Modeling Area (PM NA Area)		
	2010	2035	% Change
Daily Period[a]			
AM Peak (AM)	132,469	187,841	**41.8%**
PM Peak (PM)	380,135	509,440	**34.0%**
Off-Peak (OP)	1,206,159	1,587,234	**31.6%**
Vehicle Type			
Passenger VMT	1,718,763	2,284,514	**32.9%**
Truck VMT	105,132	104,201	**-0.9%**
Total VMT	**1,823,895**	**2,388,715**	**31.0%**

[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 PM NAA) 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 5.6-35 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 5.6-35
Additional ADOT&PF Roadway Links beyond FMATS Network



DMV Registration Data – ADEC obtained a dump or snapshot of statewide vehicle registrations from the Alaska Division of Motor Vehicle (DMV) as of May 2010. The Alaska DMV database includes vehicle make, model, model year, Vehicle Identification Number (VIN), vehicle class code, body style, registration status, expiration date and owner/operator address information. A subset of valid data for the Fairbanks NAA was created by extracting records from the statewide database based on current registration status and owner/operator ZIP codes located within the NAA.

As described in greater detail later under "MOVES Fleet Inputs", ADEC also applied a licensed VIN decoder to the VINs for the Fairbanks NAA subset that provided additional vehicle attribute information that was used along with the DMV attributes to classify vehicles into the MOVES Source Use Type fleet classification scheme.

Seasonal Vehicle Activity Surveys – ADEC has conducted a series of wintertime vehicle surveys in parking lots for commonly-frequented businesses (e.g., shopping centers) in Fairbanks in part as a cross-check to vehicle Inspection and Maintenance (I/M) program enforcement conducted by the Borough and to identify any seasonal variations in vehicle use. In conducting the surveys, personnel are stationed at various locations within the surveyed lots (over multiple days) and record license (and make/model) information for vehicles passing/parking within their viewing area. The results are then bounced against the DMV database to determine the each vehicle's model year.

The most recent set of parking lot surveys was conducted in early 2009. As described in detail later, this and similar earlier surveys (with sample sizes of several thousand vehicles each) have found a clear, recurrent pattern that older vehicles tend to be driven less during winter because of drivability concerns under the harsh Arctic conditions.

MOVES Fleet Inputs - Outputs from the several of the sources summarized earlier were used to develop the vehicle fleet-related inputs to the MOVES model runs. Each of these fleet-related MOVES inputs is described separately below. (The names of the individual inputs within MOVES are listed in parentheses.)

Vehicle Populations (Source Type Population & Age Distribution) - DMV registrations from the Alaska Division of Motor Vehicles (DMV) and recent 2009 Fairbanks Parking Lot Survey data provided the basis for the vehicle fleet populations and age distributions used to model the Fairbanks vehicle fleet with MOVES. As noted earlier, the DMV database includes vehicle make, model, model year, Vehicle Identification Number (VIN), vehicle class code, body style, registration status and expiration date.

Using a VIN decoding tool licensed by ADEC, supplemental information such as vehicle class, gross vehicle weight, vehicle type, body type and fuel type (e.g., gasoline vs. diesel) were also determined in order to help classify each vehicle into one of the 13 MOVES Source Use Type categories. In Attachment C, tables spanning the first 10 pages list each of the key vehicle attribute fields from the DMV database and VIN decoder outputs that were used to categorize each vehicle record into one of the 13 usage-based "Source Type" categories as defined in MOVES to characterize the vehicle fleet.

Table 5.6-58 lists each of these "Source Type" categories and identifies the primary vehicle attribute fields in either the DMV database itself (DMV) or output from the VIN decoder (Decoder) that were used to determine the Source Type for each vehicle record.

For nearly all the records, the Source Type could be conclusively determined from specific combinations of these attributes. In some cases such as Source Types 51 (Refuse Trucks) and 54 (Motorhomes), single values of the Body Style field in the DMV database were used to discern the appropriate Source Type. In other cases, Source Types were assigned based on categorical values in several attribute fields as noted in Table 5.6-58. In a few cases, vehicle make and model fields were also examined and then fed to a web-based search engine to identify whether the vehicle was a single or combination-unit truck.

As also noted in Table 5.6-58, the DMV and VIN decoder attribute data were not sufficient to distinguish between short-haul trucks (Source Types 52 and 61) and long-haul trucks (Source Types 53 and 62). All of the single and combination-unit truck records were assigned short-haul

Table 5.6-58 MOVES Vehicle Fleet Source Type Categories		
Source Type ID	Source Type Description	Primary Attributes/Sources
11	Motorcycle	Class Code (DMV), Body Style (DMV) – Categories MB and MC, Vehicle Type (Decoder), Vehicle Class (Decoder)
21	Passenger Car	Class Code (DMV), Vehicle Type (Decoder) , Vehicle Class (Decoder)
31	Passenger Truck	Class Code (DMV), Vehicle Type (Decoder) , Vehicle Class (Decoder)
32	Light Commercial Truck	Class Code (DMV), Vehicle Class (Decoder), GVWR Class (Decoder) – up to Class 5 (16,001-19,500 lb)
41	Intercity Bus	Class Code (DMV), Body Style (DMV), Vehicle Type (Decoder) , Vehicle Class (Decoder)
42	Transit Bus	Class Code (DMV), Body Style (DMV), Vehicle Type (Decoder) , Vehicle Class (Decoder)
43	School Bus	Class Code (DMV), Body Style (DMV), Vehicle Type (Decoder) , Vehicle Class (Decoder)
51	Refuse Truck	Body Style (DMV) – Category GG
52	Single Unit Short-haul Truck	Class Code (DMV), Body Style (DMV), Vehicle Class (Decoder), GVWR Class (Decoder) – Class 6 and above
53	Single Unit Long-haul Truck	Apportioned from MOVES default 52/53 splits
54	Motor Home	Body Style (DMV) – Category MH
61	Combination Short-haul Truck	Class Code (DMV), Body Style (DMV), Vehicle Class (Decoder) – Category "Truck Tractor", GVWR Class (Decoder), Fuel Type (Decoder)
62	Combination Long-haul Truck	Apportioned from MOVES default 61/62 splits

Source Type categories of either 52 or 61. The *SourceTypeYear* table in the MOVES database was then queried to extract nationwide vehicle populations (for calendar year 1999, the closest base year to those modeled) for Source Type categories 52, 53, 61 and 62. Relative splits between short- and long-haul vehicle fractions in these categories were then calculated and used to estimate the populations of long-haul single-unit (53) and combination-unit (62) vehicles in the Fairbanks fleet.

Table 5.6-59 shows the resulting summation of vehicles by their sourceTypeID as determined from the VIN decoder and DMV data for the year 2010. The 2010 population data was scaled back to 2008 values by backcasting the vehicle population based on the VMT rates of growth from 2010 to 2035. The VMT growth rates are derived for each individual HPMS vehicle type ID and then translated to MOVES source type ID. For the light duty vehicle fleet the annual rate of change in VMT was found to be 1.1%. The 2008 backcasted populations are shown in the rightmost column of Table 5.6-59.

Table 5.6-59 Fairbanks Baseline Vehicle Populations by MOVES Source Type			
Source Type ID	Source Type Description	Vehicle Populations	
		2010 DMV	2008 Backcast
11	Motorcycle	4,234[a]	4,201[a]
21	Passenger Car	25,441	25,241
31	Passenger Truck	50,102	49,708
32	Light Commercial Truck	6,309	6,259
41	Intercity Bus	98	97
42	Transit Bus	53	53
43	School Bus	372	369
51	Refuse Truck	34	34
52	Single Unit Short-haul Truck	1,100	1,091
53	Single Unit Long-haul Truck	103	103
54	Motor Home	1,898	1,883
61	Combination Short-haul Truck	694	689
62	Combination Long-haul Truck	526	522
Total Vehicle Fleet		**90,964**	**90,248**

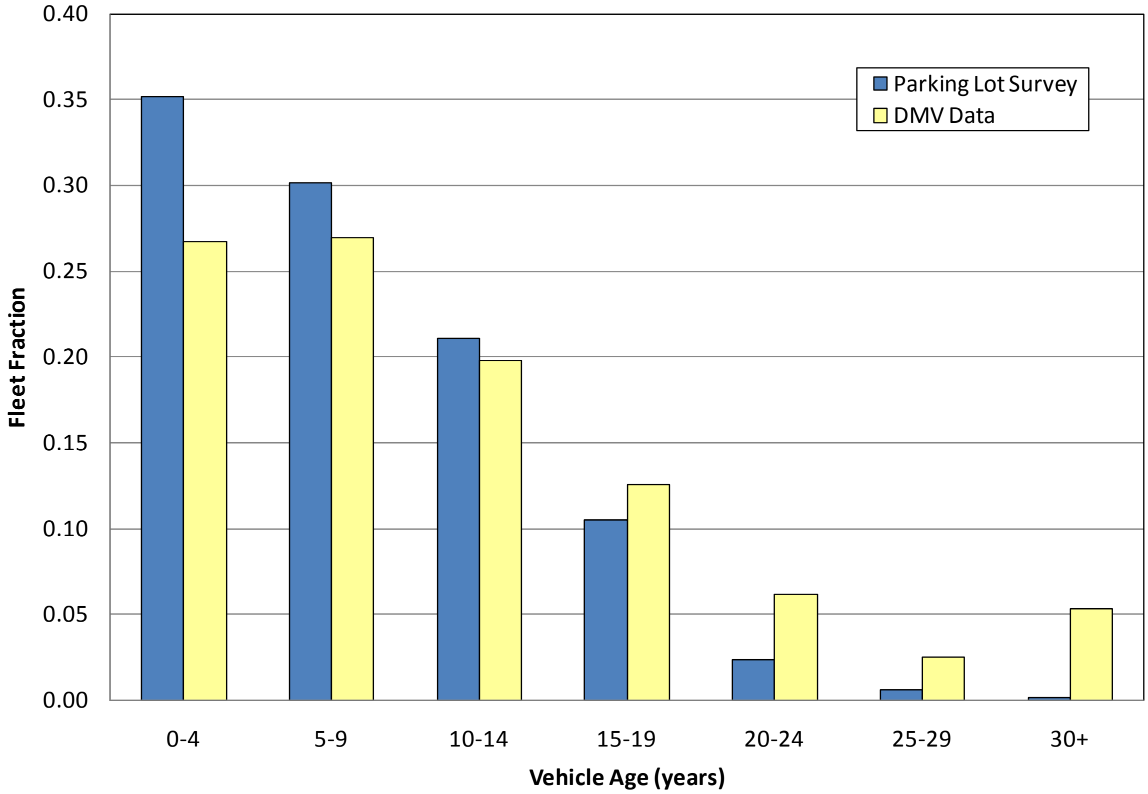
[a] As explained later, motorcycle activity in Fairbanks during the winter months was assumed to be zero.

The DMV registration data also identified the model year of the vehicle, which enabled distributions of populations by vehicle age[82] to be calculated for each Source Type and input to MOVES. For the three light-duty passenger vehicle types (11-motorcycles, 21-passenger cars, and 31-passenger trucks), vehicle age distributions from winter parking lot surveys[83] conducted by ADEC in Fairbanks during January and February 2009 were used instead of those based on DMV registrations. This is because it was found in both these 2009 surveys as well as similar parking lot surveys conducted earlier by ADEC in 2005 and 2000 that older passenger vehicles are driven less during harsh winter conditions in Fairbanks.

Figure 5.6-36compares the vehicle age fractions (by age group) for light-duty passenger cars in Fairbanks developed from the DMV registrations and the Parking Lot Surveys. As Figure 5.6-36 clearly shows, vehicle fractions in the newer groups (< 15 years) from the Parking Lot Surveys are distinctly higher than from the DMV registrations. This pattern is reversed for the older vehicle groups (15 or more years old).

[82] Vehicle age in years was simply calculated by subtracting the model year from 2010, the calendar year in which the DMV database obtained.
[83] The purpose of the surveys was to collect data for assessing the performance of the I/M Program. A review of the location of the surveys found broad representation beyond the boundary of the CO nonattainment area in Fairbanks, North Pole, and Chena Ridge areas. While no data were collected in Goldstream Valley, the results sufficiently represent the $PM_{2.5}$ nonattainment area to be used in the analysis.

Figure 5.6-36
Comparison of DMV and Survey-Based Vehicle Age Distributions of Passenger Cars in Fairbanks



Another expected finding from the Fairbanks parking lot surveys is that motorcycles are simply not operated during cold wintertime conditions. Although motorcycles make up roughly 5% of the Fairbanks-registered vehicle fleet, as shown earlier in Table 5.6-59, only a single motorcycle was identified in the entire sample of over 8,500 vehicles from the 2009 Fairbanks surveys (which represents 0.01% of the survey sample).

Thus, for Source Type categories 11 (motorcycles), 21 (passenger cars) and 31 (passenger trucks), vehicle age distributions were based on the Parking Lot Survey data to reflect well-documented winter season shifts toward greater use of newer vehicles in the passenger car and passenger truck fleets as well as non-use of motorcycles during winter months. These survey-based winter seasonal adjustments for Fairbanks have been employed in wintertime emission inventories developed in previous CO SIPs and transportation conformity determinations that have been approved by EPA and FHWA.

For the remaining MOVES source type categories (32 and above), age distributions were based on the DMV registration data for Fairbanks. Attachment C contains a detailed table labeled "MOVES Age Distribution Inputs" showing the vehicle age distributions developed for each of the MOVES source types using either the DMV or Parking Lot Survey data as described above.

These age distributions developed for the 2008 Baseline fleet were also assumed to apply for future fleets in the 2015 and 2019 modeling runs.[84]

Gasoline vs. Diesel-Fueled Vehicle Fractions (AVFT Strategies) – MOVES provides users the ability to override its default nationwide based travel splits between different fuels and technologies. These Alternative Vehicle Fuel and Technology (AVFT) inputs are supplied to MOVES through the Strategies panel in the user interface, not the County Data Manager.

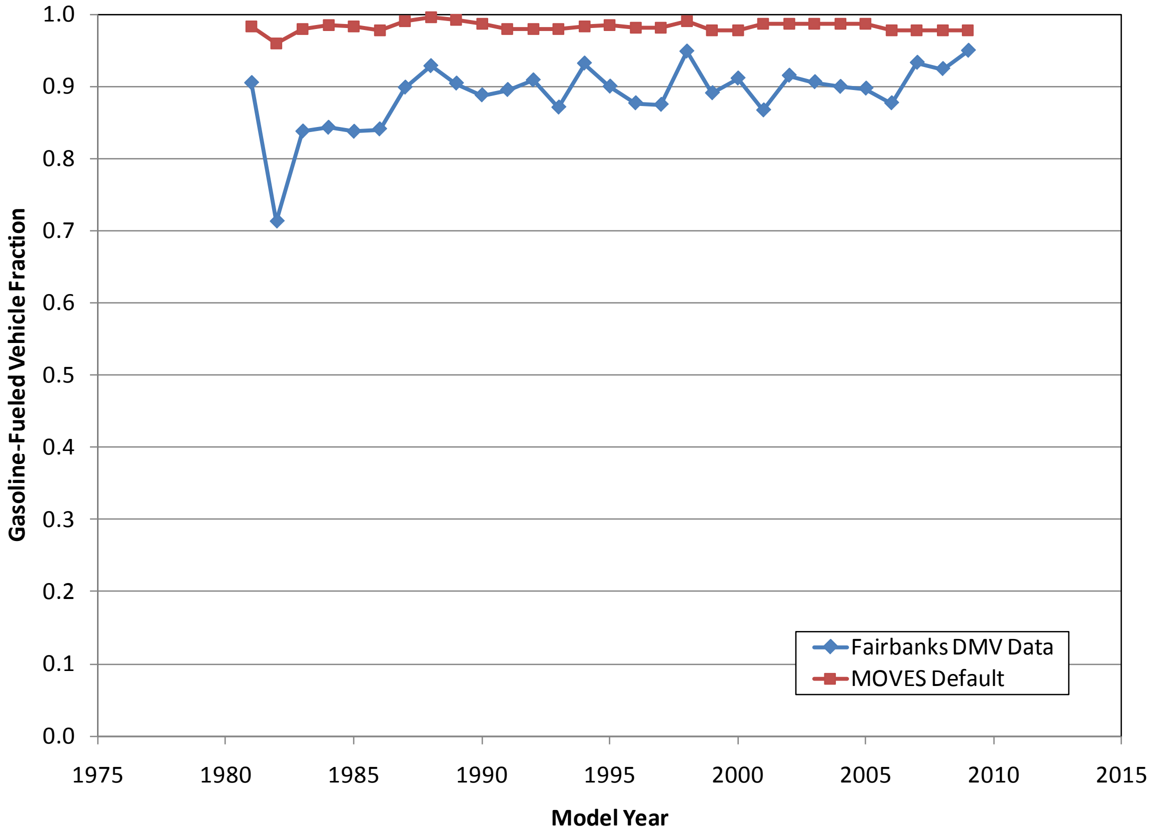
In order to account for differences in splits between gasoline- and diesel-fuel vehicles in the Fairbanks fleet compared to the U.S. as a whole, fuel fraction tables by source type and model year were also constructed using the DMV VIN decoded data described earlier. Not surprisingly, the MOVES default splits between gasoline and diesel vehicles was not representative of the Fairbanks fleet. Generally speaking, gasoline fractions were found to be lower in Fairbanks than the nationwide-based MOVES defaults (and diesel fractions were commensurately higher).

This is illustrated in Figure 5.6-37, which compares the gasoline vehicle fractions by model year for passenger trucks (MOVES Source Type 31) from the Fairbanks DMV data against the default fractions contained in MOVES. As seen in Figure 5.6-37, actual gasoline vehicle fractions for passenger trucks in Fairbanks are roughly 10% lower than the MOVES defaults (meaning diesel fractions are roughly 10% higher). Modest differences were also observed for some of the commercial vehicle categories as well.

As illustrated by the range of model years compared in Figure 5.6-37, DMV VIN decoder-based gasoline vs. diesel vehicle fractions were available only for model years 1981 through 2009 (the VIN decoder only operates on 1981 and later models). In setting up the AVFT fuel split input to MOVES, the fuel fractions must be specified by model year, not vehicle age. For earlier model years prior to 1981, the MOVES default fractions were used. For model years 2010 and later, the DMV-based fuel type fractions from model year 2009 were generally assumed to remain constant in future model years except in the passenger truck category where the MOVES defaults reflect a modest increase in diesel penetration in future model years. For passenger trucks in model years 2010 and later, the MOVES defaults were used.

[84] Although new vehicle sales nationwide have decreased during the last two or three years due to rising fuel prices and the economic recession, it is difficult to forecast when new vehicle sales will return to previous levels. Thus, although the baseline fleet inputs used in the analysis reflect recent depressed sales patterns, the future year fleets do as well. This constant age distribution assumption over time avoids the problem of under-representing emissions in future years due to shifts toward increased new vehicle fractions that cannot be predicted with any certainty. If new vehicle sales return to earlier historical levels, the constant age distribution assumption reflected in this analysis will be conservative (i.e., it will understate future fleet emission reductions).

Figure 5.6-37
Comparison of Passenger Truck Gasoline-Fuel Vehicle Fractions by Model Year
Fairbanks DMV Data vs. MOVES Defaults



Travel Activity (Vehicle Type VMT) – Estimates of VMT over the FMATS modeling network (covering the entire $PM_{2.5}$ NAA) from the TransCAD travel model link output files were processed and input to MOVES through the "Vehicle Type VMT" input within the County Data Manager. The Vehicle Type VMT input must be in units of VMT per year, not VMT per day. The annual VMT must also be supplied by "HPMS Vehicle Type" which is essentially an aggregated version of the 13-category MOVES Source Type scheme. Since states are required to provide periodic travel (i.e., VMT) estimates to FHWA via the Highway Performance Monitoring System (HPMS), EPA has designed MOVES to accept VMT input by these HPMS Vehicle Type categories.

Table 5.6-60 shows the mapping of Source Type to HPMS Vehicle Type categories. It also shows how the Fairbanks baseline vehicle populations shown earlier in Table 5.6-59 were aggregated into the HPMS Vehicle Type categories.

The green and tan cell shading in Table 5.6-60 shows where the separate Passenger Vehicle VMT and Truck VMT outputs from the TransCAD transportation model were allocated. Passenger VMT applies to Source Types 11, 21, and 31 (shown in green) and Truck VMT applies to the remainder of the fleet covering Source Types 32 and above (and shown in tan).

Table 5.6-60 MOVES Source Type to HPMS Vehicle Type Mapping					
Source Type ID	Source Type Description	HPMS VehType ID	HPMS Vehicle Type Description	2010 Baseline Vehicle Popn.
11	Motorcycle	10	Motorcycles	4,234
21	Passenger Car	20	Passenger Cars	25,441
31	Passenger Truck	30	Other 2 axle-4 tire vehicles	**50,102**
32	Light Commercial Truck			**6,309**
41	Intercity Bus	40	Buses	523
42	Transit Bus			
43	School Bus			
51	Refuse Truck	50	Single Unit Trucks	3,135
52	Single Unit Short-haul Truck			
53	Single Unit Long-haul Truck			
54	Motor Home			
61	Combination Short-haul Truck	60	Combination Trucks	1,220
62	Combination Long-haul Truck			
Total Vehicle Fleet				90,964

These allocations were assumed based on a review of the FHWA Vehicle Classification Count scheme[85] used by ADOT&PF to collect volume counts by individual vehicle classification and on which the separate travel model estimates of Passenger Vehicle and Truck VMT were based (see Attachment C).

This FHWA vehicle classification scheme is listed below.

Single Unit
- Class 01: Motorcycles
- Class 02: Automobiles, Automobiles with trailers
- Class 03: Pickup Trucks, Pickup Trucks with Trailers
- Class 04: Buses (2 or 3 axles)
- Class 05: Delivery Trucks, Recreational Vehicles, Dump Trucks (2 axles, 6 Tires)
- Class 06: Dump Trucks, Recreational Vehicles (3 axles)
- Class 07: Concrete Trucks, Fuel or Propane Delivery Trucks (4 or more axles)

Single Trailer
- Class 08: Tractor/Truck with Trailer (2 axles, 6 tires)
- Class 09: Tractor/Truck with Trailer (3axles)
- Class 10: Tractor/Truck with Trailer (4 or more axles)

[85] "2006, 2007, 2008 Annual Traffic Volume Report, Northern Region," Alaska Department of Transportation and Public Facilities, 2009.

<u>Multi- Trailer</u>

- Class 11: Tractor/Truck with 2 Trailers (5 axles)
- Class 12: Tractor/Truck with 2 or more Trailers (6 axles)
- Class 13: Tractor/Truck with 2 or more Trailers (7 or more axles)

The separate Truck VMT travel model outputs correspond to FHWA Class 04 and higher vehicles. Comparing this FHWA scheme to the Source Type scheme in MOVES indicates that FHWA Class 04 and higher closely represents MOVES Source Types 32 and higher. (See Table 5.6-58 for a listing of the Source Type categories.)

As highlighted by the boldface populations in the rightmost column of Table 5.6-60, this split of Passenger and Truck VMT from the travel model outputs falls within HPMS Vehicle Type category 30, which contains both passenger and light commercial trucks. Thus in developing the HPMS Vehicle Type VMT inputs to MOVES, separate allocations of Source Types 31 and 32 within HPMS Vehicle Type 30 were maintained until the end of the calculations.

The next step in calculating the HPMS Vehicle Type VMT inputs consisted of extracting average annual mileage per vehicle by HPMS Vehicle Type categories from MySQL database[86] underlying the MOVES model. This was done by dividing annual VMT by HPMS Vehicle Type category in the MOVES database table *HPMSVTypeYear* (for the MOVES default baseline year of 1999) by MOVES default vehicle populations (also for the model's 1999 base year) contained in the *SourceTypeYear* table after the Source Type populations were allocated into the corresponding HPMS Vehicle Type categories.

Table 5.6-61 shows these data from the MOVES database and the calculated annual mileage per vehicle by HPMS Vehicle Type category.

Table 5.6-61
Calculation of Annual Mileage per Vehicle by HPMS Vehicle Type

HPMS Vehicle. Type ID	HPMS Vehicle Type Description	Source Type Categories Contained	Base Year Annual VMT (millions)	Base Year Vehicle Population	**Avg. Annual Mileage (per vehicle)**
10	Motorcycle	11	10,600	4,173,870	**2,540**
20	Passenger Car	21	1,568,640	130,163,000	**12,051**
30	Other 2 axle-4 tire vehicles	31,32	900,735	76,296,500	**11,806**
40	Buses	41,42,43	7,657	732,189	**10,458**
50	Single-Unit Trucks	51,52,53,54	70,274	5,726,791	**12,271**
60	Combination Trucks	61,62	132,358	1,887,707	**70,116**

[86] The MOVESDB20100515 version of the database was used. This was the latest version released by EPA at the time of the conformity analysis and the initial SIP inventory development.

It is important to note that the MOVES base year 1999 data and resulting annual mileage per vehicle by HPMS Vehicle Type was used only to develop relative scaling factors by HPMS Vehicle Type to apply to the actual Passenger VMT and Truck VMT estimates from the Fairbanks travel model runs. The Fairbanks travel model VMT cannot simply be allocated to the HPMS scheme based on vehicle populations because the annual mileage driven per vehicle differs significantly across some of the HPMS Vehicle Type categories (ranging from 2,540 miles/year for motorcycles to 70,116 miles/year for combination trucks). Thus, the relative differences in annual mileage between HPMS Vehicle Type categories were used to scale the 2010 Fairbanks vehicle populations by HPMS category shown earlier in Table 5.6-60 to annual VMT values. These values were then normalized so that when summed across HPMS categories, they matched the total VMT from the travel model outputs and preserved the travel model splits between Passenger and Truck VMT.

A detailed table showing these calculations labeled "Calculation of VMT Allocations by HPMS Vehicle Type Category" is supplied in Attachment C.

Table 5.6-62 presents the resulting annual VMT by HPMS Vehicle Type category inputs generated from the 2010 and 2035 TransCAD model runs. In the absence of travel model outputs for 2008 and 2015, MOVES annual VMT inputs for those years were developed by linear interpolation (2015) and extrapolation (2008) of the 2010 and 2035 VMT by HPMS Source Type. (The highlighted columns in Table 5.6-62 represent the years [2010 and 2035] for which travel model outputs were available.)

Table 5.6-62
MOVES HPMS Vehicle Type VMT (VMT/year) Inputs by Analysis Year for FMATS Modeling Network

HPMS Vehicle. Type ID	HPMS Vehicle Type Description	Extrapolated 2008	2010	Interpolated 2015	Interpolated 2019	2035
10	Motorcycle	7,363,918	7,422,302	7,910,930	8,301,832	9,865,440
20	Passenger Car	209,971,828	211,636,581	225,569,112	236,715,136	281,299,235
30	Other 2 axle-4 tire vehicles	418,980,729	422,302,600	449,156,427	470,639,489	556,571,737
40	Buses	1,020,906	1,029,000	1,027,177	1,025,718	1,019,884
50	Single-Unit Trucks	7,180,716	7,237,648	7,224,823	7,214,563	7,173,523
60	Combination Trucks	15,967,031	16,093,625	16,065,107	16,042,293	15,951,036
Total Vehicle Fleet – Annual VMT		**660,485,128**	**665,721,757**	**706,953,576**	**739,939,032**	**739,939,032**
Total Vehicle Fleet – Daily VMT		**1,809,548**	**1,823,895**	**1,936,859**	**2,027,230**	**2,027,230**

At the bottom of Table 5.6-62, total fleet VMT is shown on both an annual and average day basis, the latter for comparison to the travel model daily VMT outputs summarized earlier in Table 5.6-57.

It should also be noted that the SourceType population inputs described earlier for the 2010 base year were calculated for the 2008 and 2015 analysis years by scaling the VMT for each analysis year in Table 5.6-62against the actual 2010 base year vehicle populations presented earlier in Table 5.6-59 and Table **5.6-60**. In other words, the VMT growth over time reflected in Table 5.6-62 was applied to baseline 2008 and future 2015 vehicle population.

This approach assumed that the annual mileage per vehicle was constant across all analysis years. Although one could estimate projected trends of VMT by vehicle type based on a series of MOVES national scale default runs, trends in annual mileage accumulation rates can vary by urban area depending on the growth rate and demographics of each area. Trends in annual mileage rates are probably fairly small for an area like Fairbanks with very mild growth projected in the vehicle fleet and transportation network. Use of national scale MOVES runs would be based on nationwide projections of per-vehicle annual VMT over time that may or may not track well with Fairbanks; thus, annual mileage rates per vehicle were simply held constant over time given the mild growth projected for Fairbanks at this time.

VMT on roadways outside the FMATS travel modeling network was calculated using the aforementioned spatial roadway VMT layer developed from merging the ADOT&PF Road Centerlines shapefile with 2008 AADT traffic volumes for those roads published by ADOT&PF's Northern Region office. Within ArcGIS, a masking operation was performed to discard the Road Centerlines layer segments corresponding to roadways already in and accounted from the FMATS travel model network. For 2008, total "outside FMATS network" VMT was 500,542 miles per annual average day, which was about 3.5 times lower than the total daily VMT within the FMATS network. VMT growth in future years and the distribution by HPMS vehicle type was assumed to be the same as for that within the FMATS network.

Table 5.6-63 shows the resulting total VMT by HPMS Vehicle Type category for the entire Grid 3 attainment modeling domain, including the contribution from outside network travel based on the ADOT&PF data.

Table 5.6-63
MOVES HPMS Vehicle Type VMT (VMT/year) Inputs by Analysis Year for Entire Grid 3 Modeling Domain

HPMS Vehicle. Type ID	HPMS Vehicle Type Description	Extrapolated 2008	2010	Interpolated 2015	Interpolated 2019	2035
10	Motorcycle	9,400,862	9,475,397	10,099,184	10,598,214	12,594,334
20	Passenger Car	268,052,466	270,177,708	287,964,139	302,193,283	359,109,859
30	Other 2 axle-4 tire vehicles	534,875,647	539,116,386	573,398,293	600,823,819	710,525,920
40	Buses	1,303,301	1,313,634	1,311,306	1,309,444	1,301,995
50	Single-Unit Trucks	9,166,985	9,239,665	9,223,293	9,210,195	9,157,802
60	Combination Trucks	20,383,697	20,545,308	20,508,902	20,479,777	20,363,278
Total Vehicle Fleet – Annual VMT		**843,182,958**	**849,868,099**	**902,505,117**	**944,614,731**	**1,113,053,189**
Total Vehicle Fleet – Daily VMT		**2,310,090**	**2,328,406**	**2,472,617**	**2,587,986**	**3,049,461**

Other MOVES Inputs – The remaining MOVES modeling inputs representing the Fairbanks $PM_{2.5}$ nonattainment area included seasonal, daily and diurnal travel fractions; travel activity by speed range (or bin) and roadway type; freeway ramp fractions; ambient temperature profiles; I/M program inputs; and fuel specifications. Each of these inputs was supplied to MOVES to represent Fairbanks specific conditions through the model's County Data Manager Importer and are discussed separately below.

Monthly, Day-of-Week and Hourly VMT Fractions – In conjunction with annual VMT by HPMS Vehicle Type, MOVES also requires inputs of monthly, weekday/weekend, and hourly travel fractions. Based on data assembled by ADOT&PF from 2009 seasonal traffic counts, traffic within the FMATS modeling area exhibits a seasonal variation such that roughly 92% of annual average daily travel within the $PM_{2.5}$ nonattainment area occurs on average winter days (with 108% occurring on average summer days). These seasonal variations were incorporated into the MonthVMTFraction input table.

Day-of-week fractions were set to assume that travel levels are the same on weekends as weekdays. In the absence of a weekend or seven-day travel model, this is a reasonable assumption.

Hourly VMT fractions were defined based on diurnal trip percentages used to support the travel model development and validation that are listed in Attachment B.

Travel by Speed Bin and Roadway Type (Average Speed & Road Type Distributions) – Link-level TransCAD model output files were processed to prepare these two sets of MOVES inputs for each analysis year.

The roadway type classification scheme employed in MOVES consists of the following five categories:

1. Off-Network;
2. Rural, Restricted Access;
3. Rural, Unrestricted Access;
4. Urban, Restricted Access; and
5. Urban, Unrestricted Access.

The "Off-Network" category is used by MOVES to represent engine-off evaporative or starting emissions that occur off of the travel network. For SIP and regional conformity analysis, EPA's MOVES guidance indicated that the user must supply Average Speed Distribution and Road Type Distribution inputs for the remaining on-network road types (2 through 5), but direct MOVES to calculate emissions over all five road types. In this manner, starting and evaporative emissions are properly calculated and output.

The first of the two sets of inputs, Average Speed Distributions, consists of time-based[87] (not distance-based) tabulations of the fractions of travel within each of MOVES' 16 speed bins (at 5 mph-wide intervals) by road type and hour of the day. These inputs were calculated from the TransCAD link outputs by time of day. The TransCAD outputs consisted of travel times, average speeds and vehicle volumes for each link in the expanded modeling network for each of three daily periods:

1) AM Peak (7-9 AM);
2) PM Peak (3-6 PM); and
3) Off-Peak (9 AM-3 PM, plus 6 PM-7 AM).

Spreadsheet calculations were performed on the TransCAD link outputs to calculate time-based travel (multiplying link travel time by vehicle volume to get vehicle hours traveled or VHT) across all links. The link VHT was then allocated by MOVES road type and average speed bin. (The link classification scheme employed in the TransCAD modeling could easily be translated to the MOVES Rural/Urban and Limited/Unlimited Access road types.) Normalized speed distributions (across all 16 bins) were then calculated for each road type and time of day period and formatted for input into MOVES.

MOVES allows these Average Speed Distribution inputs to be specified separately by Source Type (i.e., vehicle category). Thus, individual distributions were developed from Passenger VHT and Truck VHT tabulations of the TransCAD outputs. The Passenger VHT was available for each of the three modeling periods. Truck VMT was only available on a single daily basis. (As stated earlier, Passenger activity was applied to MOVES Source Types 11, 21, and 31, while Truck activity was applied to categories 32 and higher.)

Attachment C contains tabular summaries of the normalized average speed distribution inputs developed from the 2010 and 2035 TransCAD outputs. (Distributions for 2015 and 2019 were interpolated from the 2010 and 2035 outputs.)

Similar spreadsheet calculations were also performed to tabulate distance-based (i.e., VMT-based) Road Type Distribution inputs to MOVES. The resulting tabulations and normalized Road Type distributions are also provided in Attachment C. (Road type distributions for 2015 and 2019 were similarly interpolated from the 2010 and 2035 TransCAD outputs.)

Freeway Ramp Fractions (Ramp Fraction) – MOVES uses default values of 8% (or 0.08) to represent the fraction of time-based limited access roadway travel (Road Types 2 and 4) that occur on freeway ramps. Fairbanks-specific ramp fraction values were tabulated from the TransCAD link level outputs and were supplied to MOVES in the Ramp Fraction input section of the County Data Manager to override the nationwide-based defaults.

These Fairbanks ramp travel fractions are presented below in Table 5.6-64 as tabulated from the 2010 and 2035 travel model outputs. As shown in Table 5.6-64, the Fairbanks ramp fractions in

[87] MOVES requires Average Speed Distribution inputs on a time-weighted basis and Road Type Distribution inputs on a distance-weighted basis.

urbanized areas are higher than the default values in MOVES, reflecting the fact that shorter freeway lengths (with resulting higher ramp fractions) are driven in Fairbanks compared to the nationwide-based defaults.

Table 5.6-64
TransCAD Ramp Fractions

	Fraction of Time-Based Limited Access Travel on Ramps			
	2010 Baseline		2035 LRTP	
	Rural	Urban	Rural	Urban
Daily Ramp Travel Fractions	0.062	0.181	0.068	0.208

For the 2008, 2015 and 2019 MOVES inputs, these values were calculated based on the linear rate of change in the ramp travel fractions between 2010 and 2035. The results of that calculation are shown below in Table 5.6-65.

Table 5.6-65
Ramp Fraction Inputs by SIP Modeling Year

	Fraction of Time-Based Limited Access Travel on Ramps					
	2008 Base		2015 Forecasted		2019 Forecasted	
	Rural	Urban	Rural	Urban	Rural	Urban
Daily Ramp Travel Fractions	0.061	0.179	0.063	0.187	0.064	0.191

Ambient Temperature Profiles (Meteorology Data) – Episodic average temperature profiles were created per the guidance in the SMOKE-MOVES model documentation using the MET4MOVES. Some MET4MOVES code modifications were made to allow for sub-monthly temperature profiles to be generated. Code changes are detailed in the SMOKE modeling appendix. Different temperature profiles are required as inputs for a number of MOVES runs to create lookup tables for rate per distance, rate per vehicle and rate per profile activities. The modified MET4MOVES program was operated using a version of the run_met4moves.csh script included with the 2.7.1 version of SMOKE. The dates of the episode days, surrogates and ASSIGNS file were updated to reflect the SMOKE configuration for the baseline modeling episodes. Two script runs of the *run_met4moves.csh* file were performed to generate different average meteorology profiles for each episode. The MET4MOVES program requires the met field inputs already be processed through the Meteorology-Chemistry Input Processor (MCIP) software.

The domain-wide ground level average relative humidity (RH), minimum and maximum temperatures for each modeling episode are presented in Table 5.6-66. These outputs have been rounded down to the nearest 5 degree increment in the case of the minimum temperature and up to the nearest 5 degree increment in the maximum temperature case.

Table 5.6-66
Fairbanks Model Domain Episodic Meteorology Conditions

Episode	Relative Humidity	Min. Temperature (F)	Max.Temperature (F)
Episode 1 (Jan - Feb)	72.3%	-50.0	30.0
Episode 2 (Nov)	82.3%	-20.0	35.0

Daily temperature profiles for each of the episodes are presented in Table 5.6-67. These profiles have been scaled to reflect the maximum and minimum temperatures for those respective episodes. These profiles form the basis of the RPV and RPP MOVES simulation meteorology inputs that are generated by the RunSpec generator script.

Table 5.6-67
Fairbanks Model Domain Episodic Average Temperature Profiles

Hour	Episode 1 Temperature (F)	Episode 2 Temperature (F)
1	-33.7	-17.8
2	-38.0	-20.0
3	-42.9	-18.5
4	-47.2	-13.1
5	-48.2	-16.2
6	-46.4	-17.1
7	-46.6	-15.6
8	-48.5	-19.8
9	-50.0	-18.8
10	-48.9	-18.2
11	-48.7	-9.0
12	-36.5	4.7
13	-10.6	14.7
14	15.7	26.6
15	30.0	35.0
16	29.1	32.3
17	12.3	19.7
18	-3.0	8.9
19	-11.6	0.8
20	-18.1	1.4
21	-22.1	-2.1
22	-26.2	-9.8
23	-31.4	-14.0
24	-29.2	-17.4

The RunSpec generator script has been rewritten to use the average RH, minimum temperature, maximum temperature and average profiles to create the RPD, RPV and RPP meteorology input fields.

I/M Program Data (I/M Programs) – Since the Fairbanks Inspection and Maintenance (I/M) program was terminated at the end of 2009, the "Use I/M Program" input element to MOVES for the forecast years of 2015 and 2019 was set from "Yes" to :No" to account for the elimination of the program.

For the 2008 base year, I/M program characteristics for the Fairbanks I/M program stored by EPA in the MOVES database were used to represent the existence of the I/M Program, with the exception of a 96% compliance rate, estimated from local enforcement data.

According to EPA's MOVES documentation, I/M emission benefits are only assumed for HC, CO and NO_x. No I/M benefits for particulate emissions are assumed in MOVES.

Fuel Specifications (Fuel Supply) – EPA has developed detailed fuel specifications (e.g., RVP, oxygen content, sulfur content, etc.) for different gasoline and diesel fuel blends used in each county of the U.S. and has loaded these specifications into the *FuelFormulation* and *FuelSupply* tables in the MOVES default database. (The first of these tables identifies the detailed properties of a specific fuel blend, the second table identifies that state and county of the U.S. and the calendar year to which it applies.) Semi-annual fuel survey data collected by the Alliance of Automobile Manufacturers (AAM) were reviewed to confirm whether the default fuel properties for Fairbanks defined in MOVES were correct. Retail gasoline data for the 2008 winter for Fairbanks from the AAM surveys indicated that sulfur and oxygen contents in MOVES reasonably matched measured levels.

However, Fairbanks diesel blends are not included in the AAM surveys. MOVES assumed diesel fuel sulfur content of 43 ppm in 2008 through 2011 and 11 ppm in 2012 and later years. These sulfur levels are believed to be reasonably representative of those required under Alaska's Ultra Low-Sulfur Diesel (ULSD) regulation.

Thus, MOVES default gasoline and diesel fuel specifications for Fairbanks were used in the analysis.

MOVES Data Importing and Execution and SMOKE Processing

Once all of the inputs were assembled, MOVES command input or "RunSpec" files and input importer scripts and processing workflows were set up to generate model runs and feed outputs to SMOKE as summarized below.

RunSpec and Importer Generation (SMOKE-MOVES) – Version 0.20 of the RunSpec generator script from the SMOKE-MOVES tool was used to create the MOVES RunSpec and import files for the RPD, RPV and RPP simulations in the baseline. Modifications to the script were made to allow for the use of Excel files and spreadsheet tabs in the importing process with the exception of the meteorology inputs. AVFT data was added through a separate text file via a change to the

RunSpec configuration script. The RunSpec run control input for POLLUTANTS was set to both OZONE and PM in order to output pollutants for direct $PM_{2.5}$, precursor pollutants and CO.

The met profile inputs for the RPD, RPV and RPP rates are created in the RunSpec generator script based on the outputs from the modified MET4MOVES program. A new meteorology type was added to signal the creation of RPD and RPV temperature profiles from the temperature maximums, minimums and profiles extracted from the episode-processed meteorology files. Table 5.6-68 lays out the number of temperature profiles created for each of the model episodes and rates calculations.

Table 5.6-68
Fairbanks MOVES Rates Temperature Profile Count

Rates Scenario	Episode 1	Episode 2
RPD	1	1
RPV	8	11
RPP	66	36
Total Profiles	**75**	**48**

The RPD, RPV and RPP inventory importer scripts were run to import each of these different profiles with the 2008 baseline vehicle activity, population and fleet characteristics.

<u>MOVES Simulations</u> – Following the importing of the RPD, RPV and RPP input data the RunSpec scripts were configured to execute a series of 75 MOVES runs for episode 1 and 48 MOVES runs for Episode 2. These simulations were performed with MOVES version 20100826 installed on a custom-built Linux computer (Intel i7 950 4 core/8 thread, 8 GB system memory, 1 TB hard disk drive) running Ubuntu 10.04 OS.

<u>Lookup Table Generation</u> – The SMOKE-MOVES tools post-processing script was adapted for use in the extraction of lookup tables from the series of scripted MOVES simulations. Lookups are generated covering the range of pollutants specified earlier under “RunSpec and Importer Generation.” Some code changes were needed due to address a bug in the 0.20 version of the code described in the “MOVES and SMOKE Bug Fixes” section. Lookup tables are extracted into text files that are then moved into the SMOKE inventory mobile source assignment directories.

<u>SMOKE Processing</u> – Three separate run scripts were used for the processing of the rate per distance, rate per vehicle and rate per profile inventories through SMOKE. Inventory processing through SMOKE utilizes the *smkinvenis* program described in greater detail in the 5.8 *Modeling Emissions Processing* section. The SCC-specific summaries were generated during the SMOKE runs for these emissions inventories.

ON-ROAD INVENTORY SUMMARIES

SMOKE processing of MOVES2010a-based emission rates as described in the preceding sub-sections produced detailed sets of episodic on-road emissions (in tons/day) for each day, hour and grid cell within each modeling episode.

Table 5.6-69 through Table 5.6-74 list baseline 2008 on-road daily emissions (averaged across all days and hours) by SCC code for each modeling episode. For each episode, separate tabulations are provided for the Rate per Distance (RPD), Rate per Vehicle (RPV) and Rate Per Profile (RPP) "modes" of the on-road inventory. Table 5.6-69 through Table 5.6-71 list RPD, RPV and RPP emissions, respectively for Episode 1; Table 5.6-72 through Table 5.6-74 show similar tabulations for Episode 2. Totals summed across all SCC codes in the on-road fleet are listed at the bottom of each table. Gaseous NO_x, SO_x and TOG are summed totals of their component species. Particulate matter is presented as total $PM_{2.5}$ and also broken out into components in the spreadsheet for organic carbon (POC), elemental carbon (PEC), sulfate (PSO_4), nitrate (PNO_3) and other particulates (PMFINE).

Finally, Table 5.6-75 presents a summary of on-road emissions for the 2008 base year, showing total emissions by mode (RPD, RPV, RPP) summed across all applicable SCC codes for separately for each episode and for a weighted average across both modeling episodes, using the number of days in each episode (Episode 1=19 days, Episode 2=16 days).

Table 5.6-69
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001110	7.6E-01	7.8E-02	4.7E-03	1.7E-03	2.0E-02	1.7E-02	3.6E-03	1.5E-05	1.3E-06	2.9E-03	2.3E-02
2201001130	3.6E-01	3.9E-02	2.3E-03	9.2E-04	1.3E-02	5.8E-03	1.3E-03	1.3E-05	7.7E-07	1.2E-03	8.2E-03
2201001150	1.6E-01	1.8E-02	1.0E-03	4.2E-04	5.8E-03	2.6E-03	5.7E-04	5.8E-06	3.5E-07	5.3E-04	3.7E-03
2201001170	6.3E-01	7.0E-02	4.0E-03	1.6E-03	2.3E-02	8.4E-03	1.8E-03	2.3E-05	1.4E-06	1.8E-03	1.2E-02
2201001190	1.7E-01	1.9E-02	1.1E-03	4.4E-04	6.1E-03	2.3E-03	5.0E-04	6.1E-06	3.7E-07	4.8E-04	3.3E-03
2201001210	6.6E-01	7.3E-02	4.2E-03	1.7E-03	2.4E-02	9.8E-03	2.2E-03	2.4E-05	1.4E-06	2.0E-03	1.4E-02
2201001230	1.0E+00	7.6E-02	4.0E-03	1.5E-03	2.0E-02	2.8E-02	6.0E-03	1.5E-05	1.8E-06	4.8E-03	3.8E-02
2201001250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201001270	3.3E-01	3.6E-02	2.1E-03	8.5E-04	1.2E-02	5.4E-03	1.2E-03	1.2E-05	7.1E-07	1.1E-03	7.7E-03
2201001290	3.8E-01	4.2E-02	2.5E-03	1.0E-03	1.4E-02	6.3E-03	1.4E-03	1.4E-05	8.3E-07	1.3E-03	9.0E-03
2201001310	1.9E-01	2.1E-02	1.2E-03	5.0E-04	7.0E-03	3.0E-03	6.6E-04	7.0E-06	4.2E-07	6.1E-04	4.3E-03
2201001330	1.6E-01	1.8E-02	1.0E-03	4.2E-04	5.8E-03	2.3E-03	5.1E-04	5.8E-06	3.5E-07	4.8E-04	3.3E-03
2201020110	1.3E+00	1.5E-01	4.8E-03	2.4E-03	3.3E-02	2.8E-02	2.1E-03	2.3E-05	1.1E-06	4.9E-03	3.5E-02
2201020130	6.5E-01	7.4E-02	2.4E-03	1.4E-03	2.3E-02	9.2E-03	6.9E-04	2.2E-05	9.3E-07	1.9E-03	1.2E-02
2201020150	2.9E-01	3.4E-02	1.1E-03	6.3E-04	1.0E-02	4.2E-03	3.1E-04	9.8E-06	4.2E-07	8.5E-04	5.3E-03
2201020170	1.1E+00	1.3E-01	4.2E-03	2.4E-03	4.0E-02	1.3E-02	1.0E-03	3.8E-05	1.6E-06	2.8E-03	1.7E-02
2201020190	3.1E-01	3.6E-02	1.1E-03	6.6E-04	1.1E-02	3.6E-03	2.8E-04	1.0E-05	4.5E-07	7.7E-04	4.7E-03
2201020210	1.4E+00	1.6E-01	5.1E-03	3.0E-03	4.8E-02	1.8E-02	1.4E-03	4.6E-05	2.0E-06	3.8E-03	2.3E-02
2201020230	1.9E+00	1.5E-01	4.6E-03	2.5E-03	3.8E-02	5.3E-02	3.9E-03	2.8E-05	1.6E-06	9.1E-03	6.6E-02
2201020250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201020270	5.9E-01	6.8E-02	2.2E-03	1.3E-03	2.1E-02	8.6E-03	6.5E-04	2.0E-05	8.6E-07	1.8E-03	1.1E-02
2201020290	6.5E-01	7.4E-02	2.4E-03	1.4E-03	2.3E-02	9.5E-03	7.2E-04	2.2E-05	9.5E-07	1.9E-03	1.2E-02
2201020310	3.5E-01	4.0E-02	1.3E-03	7.5E-04	1.2E-02	4.8E-03	3.6E-04	1.2E-05	5.1E-07	9.9E-04	6.2E-03
2201020330	2.9E-01	3.3E-02	1.1E-03	6.2E-04	1.0E-02	3.7E-03	2.8E-04	9.8E-06	4.2E-07	7.8E-04	4.8E-03
2201040110	7.4E-01	8.2E-02	2.7E-03	1.3E-03	1.8E-02	1.5E-02	1.1E-03	1.2E-05	5.6E-07	2.6E-03	1.9E-02
2201040130	3.3E-01	3.9E-02	1.3E-03	7.0E-04	1.1E-02	4.8E-03	3.6E-04	9.9E-06	4.2E-07	9.5E-04	6.1E-03
2201040150	1.5E-01	1.8E-02	5.7E-04	3.2E-04	4.9E-03	2.2E-03	1.6E-04	4.5E-06	1.9E-07	4.3E-04	2.8E-03
2201040170	5.8E-01	6.8E-02	2.2E-03	1.2E-03	1.9E-02	6.9E-03	5.3E-04	1.8E-05	7.4E-07	1.4E-03	8.9E-03
2201040190	1.6E-01	1.9E-02	6.0E-04	3.4E-04	5.2E-03	1.9E-03	1.4E-04	4.8E-06	2.0E-07	3.9E-04	2.4E-03
2201040210	6.5E-01	7.8E-02	2.5E-03	1.4E-03	2.2E-02	8.8E-03	6.7E-04	2.0E-05	8.5E-07	1.8E-03	1.1E-02
2201040230	9.6E-01	7.8E-02	2.4E-03	1.3E-03	1.9E-02	2.7E-02	2.0E-03	1.4E-05	8.0E-07	4.7E-03	3.4E-02
2201040250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201040270	3.0E-01	3.5E-02	1.1E-03	6.5E-04	1.0E-02	4.4E-03	3.3E-04	1.0E-05	4.3E-07	9.0E-04	5.7E-03

Table 5.6-69
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201040290	3.3E-01	3.8E-02	1.2E-03	7.2E-04	1.1E-02	4.9E-03	3.7E-04	1.1E-05	4.7E-07	9.9E-04	6.3E-03
2201040310	1.9E-01	2.2E-02	7.1E-04	4.1E-04	6.6E-03	2.6E-03	2.0E-04	6.3E-06	2.7E-07	5.4E-04	3.4E-03
2201040330	1.6E-01	1.8E-02	5.9E-04	3.4E-04	5.5E-03	2.0E-03	1.5E-04	5.2E-06	2.2E-07	4.2E-04	2.6E-03
2201070110	3.0E-01	3.0E-02	6.0E-04	3.5E-04	7.1E-03	7.4E-03	5.4E-04	4.1E-06	2.0E-07	1.3E-03	9.2E-03
2201070130	1.2E-01	1.3E-02	2.9E-04	1.8E-04	4.2E-03	2.1E-03	1.6E-04	2.9E-06	1.2E-07	3.9E-04	2.7E-03
2201070150	5.5E-02	5.9E-03	1.3E-04	8.1E-05	1.9E-03	9.6E-04	7.1E-05	1.3E-06	5.6E-08	1.8E-04	1.2E-03
2201070170	2.2E-01	2.3E-02	5.1E-04	3.2E-04	7.5E-03	3.0E-03	2.3E-04	5.2E-06	2.2E-07	5.8E-04	3.8E-03
2201070190	5.8E-02	6.2E-03	1.4E-04	8.6E-05	2.0E-03	8.2E-04	6.1E-05	1.4E-06	5.9E-08	1.6E-04	1.0E-03
2201070210	2.3E-01	2.4E-02	5.3E-04	3.3E-04	7.8E-03	3.6E-03	2.7E-04	5.4E-06	2.3E-07	6.7E-04	4.5E-03
2201070230	5.8E-01	4.1E-02	6.0E-04	4.3E-04	1.3E-02	1.2E-02	9.1E-04	5.9E-06	3.1E-07	2.1E-03	1.6E-02
2201070250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201070270	1.0E-01	1.1E-02	2.4E-04	1.5E-04	3.6E-03	1.7E-03	1.2E-04	2.7E-06	1.1E-07	3.2E-04	2.1E-03
2201070290	1.1E-01	1.2E-02	2.6E-04	1.7E-04	4.0E-03	1.8E-03	1.4E-04	2.9E-06	1.2E-07	3.5E-04	2.3E-03
2201070310	6.0E-02	6.2E-03	1.4E-04	9.0E-05	2.2E-03	9.3E-04	7.0E-05	1.6E-06	6.6E-08	1.8E-04	1.2E-03
2201070330	5.0E-02	5.2E-03	1.2E-04	7.5E-05	1.8E-03	7.2E-04	5.4E-05	1.3E-06	5.4E-08	1.4E-04	9.2E-04
2201080110	3.2E-01	8.0E-03	1.0E-04	7.4E-05	9.7E-03	2.4E-03	5.3E-04	4.3E-07	1.2E-07	4.1E-04	3.4E-03
2201080130	1.5E-01	3.4E-03	4.2E-05	3.7E-05	6.4E-03	8.4E-04	1.8E-04	2.3E-07	4.4E-08	1.4E-04	1.2E-03
2201080150	7.0E-02	1.6E-03	1.9E-05	1.7E-05	2.9E-03	3.8E-04	8.3E-05	1.1E-07	2.0E-08	6.4E-05	5.3E-04
2201080170	2.7E-01	6.0E-03	7.3E-05	6.6E-05	1.1E-02	1.2E-03	2.6E-04	4.1E-07	7.8E-08	2.1E-04	1.7E-03
2201080190	7.4E-02	1.6E-03	2.0E-05	1.8E-05	3.0E-03	3.3E-04	7.2E-05	1.1E-07	2.1E-08	5.6E-05	4.6E-04
2201080210	2.9E-01	6.3E-03	7.7E-05	6.9E-05	1.2E-02	1.4E-03	3.1E-04	4.3E-07	8.2E-08	2.4E-04	2.0E-03
2201080230	2.6E-01	6.2E-03	7.9E-05	6.2E-05	8.6E-03	4.1E-03	8.9E-04	3.6E-07	1.9E-07	6.8E-04	5.6E-03
2201080250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201080270	1.3E-01	2.9E-03	3.5E-05	3.2E-05	5.5E-03	7.3E-04	1.6E-04	2.0E-07	3.7E-08	1.2E-04	1.0E-03
2201080290	1.4E-01	3.2E-03	3.9E-05	3.5E-05	6.0E-03	8.1E-04	1.8E-04	2.2E-07	4.1E-08	1.4E-04	1.1E-03
2201080310	7.8E-02	1.7E-03	2.1E-05	1.9E-05	3.2E-03	4.1E-04	8.9E-05	1.2E-07	2.2E-08	6.9E-05	5.7E-04
2201080330	6.5E-02	1.4E-03	1.7E-05	1.6E-05	2.7E-03	3.2E-04	6.9E-05	9.8E-08	1.8E-08	5.4E-05	4.4E-04
2230001110	1.1E-04	6.7E-04	4.2E-06	6.4E-06	4.0E-05	5.0E-06	3.3E-05	4.7E-07	2.1E-09	7.6E-07	4.0E-05
2230001130	8.3E-05	4.4E-04	2.2E-06	3.8E-06	2.7E-05	4.0E-06	1.1E-05	3.0E-07	2.3E-09	9.8E-07	1.7E-05
2230001150	3.7E-05	2.0E-04	9.9E-07	1.7E-06	1.2E-05	1.8E-06	5.2E-06	1.4E-07	1.0E-09	4.4E-07	7.6E-06
2230001170	1.5E-04	7.8E-04	3.9E-06	6.7E-06	4.7E-05	7.1E-06	2.0E-05	5.3E-07	4.1E-09	1.7E-06	3.0E-05
2230001190	4.0E-05	2.1E-04	1.0E-06	1.8E-06	1.3E-05	1.9E-06	5.5E-06	1.4E-07	1.1E-09	4.7E-07	8.0E-06
2230001210	1.5E-04	8.2E-04	4.0E-06	7.0E-06	5.0E-05	7.4E-06	2.1E-05	5.5E-07	4.3E-09	1.8E-06	3.1E-05
2230001230	1.1E-04	6.1E-04	3.3E-06	5.9E-06	3.5E-05	6.0E-06	5.6E-05	4.4E-07	2.2E-09	8.8E-07	6.3E-05

Table 5.6-69
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230001250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230001270	7.3E-05	3.8E-04	1.8E-06	3.3E-06	2.4E-05	3.7E-06	9.1E-06	2.6E-07	2.2E-09	9.6E-07	1.4E-05
2230001290	8.1E-05	4.2E-04	2.0E-06	3.6E-06	2.6E-05	4.0E-06	1.0E-05	2.9E-07	2.4E-09	1.0E-06	1.5E-05
2230001310	4.3E-05	2.2E-04	1.1E-06	1.9E-06	1.4E-05	2.2E-06	5.4E-06	1.5E-07	1.3E-09	5.6E-07	8.3E-06
2230001330	3.6E-05	1.9E-04	9.0E-07	1.6E-06	1.2E-05	1.8E-06	4.5E-06	1.3E-07	1.1E-09	4.7E-07	6.9E-06
2230060110	1.6E-02	3.0E-02	2.0E-04	1.7E-04	4.6E-03	3.1E-04	1.6E-03	1.2E-05	4.4E-08	1.7E-05	2.0E-03
2230060130	1.1E-02	1.8E-02	9.4E-05	9.1E-05	3.0E-03	3.0E-04	8.0E-04	7.1E-06	4.8E-08	2.1E-05	1.1E-03
2230060150	4.9E-03	8.3E-03	4.3E-05	4.1E-05	1.4E-03	1.4E-04	3.6E-04	3.2E-06	2.2E-08	9.6E-06	5.1E-04
2230060170	1.9E-02	3.2E-02	1.7E-04	1.6E-04	5.3E-03	5.3E-04	1.4E-03	1.3E-05	8.5E-08	3.7E-05	2.0E-03
2230060190	5.1E-03	8.7E-03	4.5E-05	4.3E-05	1.4E-03	1.4E-04	3.8E-04	3.4E-06	2.3E-08	1.0E-05	5.4E-04
2230060210	2.0E-02	3.4E-02	1.7E-04	1.7E-04	5.6E-03	5.6E-04	1.5E-03	1.3E-05	8.9E-08	3.9E-05	2.1E-03
2230060230	1.7E-02	3.4E-02	1.9E-04	1.8E-04	4.9E-03	3.9E-04	1.9E-03	1.3E-05	6.0E-08	2.4E-05	2.3E-03
2230060250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230060270	9.5E-03	1.6E-02	7.6E-05	7.6E-05	2.6E-03	2.9E-04	6.5E-04	6.1E-06	4.5E-08	2.0E-05	9.6E-04
2230060290	1.0E-02	1.7E-02	8.4E-05	8.4E-05	2.9E-03	3.2E-04	7.1E-04	6.7E-06	5.0E-08	2.2E-05	1.1E-03
2230060310	5.6E-03	9.2E-03	4.5E-05	4.5E-05	1.5E-03	1.7E-04	3.8E-04	3.6E-06	2.7E-08	1.2E-05	5.7E-04
2230060330	4.6E-03	7.6E-03	3.7E-05	3.7E-05	1.3E-03	1.4E-04	3.2E-04	3.0E-06	2.2E-08	9.8E-06	4.7E-04
2230071110	7.3E-03	1.4E-02	9.2E-05	7.7E-05	2.2E-03	1.4E-04	7.4E-04	5.6E-06	2.0E-08	7.8E-06	8.9E-04
2230071130	5.0E-03	8.5E-03	4.4E-05	4.2E-05	1.4E-03	1.4E-04	3.7E-04	3.3E-06	2.2E-08	9.8E-06	5.2E-04
2230071150	2.3E-03	3.9E-03	2.0E-05	1.9E-05	6.4E-04	6.2E-05	1.7E-04	1.5E-06	1.0E-08	4.4E-06	2.3E-04
2230071170	8.9E-03	1.5E-02	7.8E-05	7.5E-05	2.5E-03	2.4E-04	6.4E-04	5.9E-06	3.9E-08	1.7E-05	9.1E-04
2230071190	2.4E-03	4.1E-03	2.1E-05	2.0E-05	6.7E-04	6.6E-05	1.7E-04	1.6E-06	1.1E-08	4.7E-06	2.5E-04
2230071210	9.3E-03	1.6E-02	8.2E-05	7.9E-05	2.6E-03	2.6E-04	6.8E-04	6.2E-06	4.1E-08	1.8E-05	9.6E-04
2230071230	7.9E-03	1.6E-02	8.8E-05	8.4E-05	2.3E-03	1.8E-04	8.6E-04	6.2E-06	2.7E-08	1.1E-05	1.1E-03
2230071250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230071270	4.5E-03	7.4E-03	3.6E-05	3.6E-05	1.2E-03	1.3E-04	3.0E-04	2.9E-06	2.1E-08	9.5E-06	4.5E-04
2230071290	5.0E-03	8.1E-03	4.0E-05	4.0E-05	1.4E-03	1.5E-04	3.3E-04	3.2E-06	2.3E-08	1.0E-05	4.9E-04
2230071310	2.7E-03	4.4E-03	2.1E-05	2.1E-05	7.3E-04	7.8E-05	1.8E-04	1.7E-06	1.3E-08	5.6E-06	2.6E-04
2230071330	2.2E-03	3.6E-03	1.8E-05	1.8E-05	6.1E-04	6.5E-05	1.5E-04	1.4E-06	1.0E-08	4.6E-06	2.2E-04
2230072110	3.5E-02	6.4E-02	4.3E-04	3.5E-04	1.0E-02	6.7E-04	3.6E-03	2.6E-05	9.5E-08	3.6E-05	4.3E-03
2230072130	2.3E-02	3.9E-02	2.0E-04	1.9E-04	6.5E-03	6.5E-04	1.7E-03	1.5E-05	1.0E-07	4.5E-05	2.4E-03
2230072150	1.0E-02	1.8E-02	9.0E-05	8.6E-05	2.9E-03	2.9E-04	7.8E-04	6.8E-06	4.6E-08	2.0E-05	1.1E-03
2230072170	4.1E-02	6.9E-02	3.5E-04	3.4E-04	1.1E-02	1.1E-03	3.0E-03	2.6E-05	1.8E-07	7.9E-05	4.3E-03
2230072190	1.1E-02	1.9E-02	9.5E-05	9.1E-05	3.1E-03	3.1E-04	8.2E-04	7.2E-06	4.9E-08	2.1E-05	1.2E-03

Table 5.6-69
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230072210	4.3E-02	7.2E-02	3.7E-04	3.5E-04	1.2E-02	1.2E-03	3.2E-03	2.8E-05	1.9E-07	8.3E-05	4.5E-03
2230072230	3.9E-02	7.7E-02	4.3E-04	4.0E-04	1.1E-02	9.0E-04	4.3E-03	3.0E-05	1.3E-07	5.5E-05	5.3E-03
2230072250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230072270	2.1E-02	3.3E-02	1.6E-04	1.6E-04	5.7E-03	6.2E-04	1.4E-03	1.3E-05	9.7E-08	4.3E-05	2.1E-03
2230072290	2.3E-02	3.7E-02	1.8E-04	1.8E-04	6.3E-03	6.8E-04	1.5E-03	1.4E-05	1.1E-07	4.7E-05	2.3E-03
2230072310	1.2E-02	2.0E-02	9.6E-05	9.5E-05	3.4E-03	3.7E-04	8.3E-04	7.6E-06	5.7E-08	2.5E-05	1.2E-03
2230072330	1.0E-02	1.6E-02	8.0E-05	7.9E-05	2.8E-03	3.0E-04	6.9E-04	6.3E-06	4.7E-08	2.1E-05	1.0E-03
2230073110	9.3E-03	4.0E-02	8.4E-05	1.4E-04	2.8E-03	5.5E-04	1.4E-03	1.0E-05	4.9E-08	2.1E-05	2.0E-03
2230073130	4.6E-03	1.9E-02	3.2E-05	6.2E-05	1.5E-03	3.4E-04	6.6E-04	5.2E-06	4.7E-08	2.2E-05	1.0E-03
2230073150	2.1E-03	8.5E-03	1.5E-05	2.8E-05	6.7E-04	1.5E-04	3.0E-04	2.3E-06	2.1E-08	9.8E-06	4.6E-04
2230073170	8.2E-03	3.3E-02	5.7E-05	1.1E-04	2.6E-03	6.0E-04	1.2E-03	9.2E-06	8.3E-08	3.8E-05	1.8E-03
2230073190	2.2E-03	9.0E-03	1.5E-05	3.0E-05	7.1E-04	1.6E-04	3.1E-04	2.5E-06	2.2E-08	1.0E-05	4.9E-04
2230073210	8.6E-03	3.5E-02	6.0E-05	1.2E-04	2.7E-03	6.3E-04	1.2E-03	9.6E-06	8.7E-08	4.0E-05	1.9E-03
2230073230	1.5E-02	7.1E-02	1.2E-04	2.4E-04	4.5E-03	9.0E-04	2.8E-03	1.9E-05	1.1E-07	4.8E-05	3.8E-03
2230073250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230073270	3.7E-03	1.5E-02	2.5E-05	5.0E-05	1.2E-03	2.8E-04	5.2E-04	4.2E-06	4.1E-08	1.9E-05	8.3E-04
2230073290	4.1E-03	1.7E-02	2.8E-05	5.5E-05	1.3E-03	3.1E-04	5.7E-04	4.6E-06	4.5E-08	2.1E-05	9.1E-04
2230073310	2.2E-03	8.9E-03	1.5E-05	2.9E-05	7.1E-04	1.7E-04	3.1E-04	2.5E-06	2.4E-08	1.1E-05	4.9E-04
2230073330	1.8E-03	7.4E-03	1.2E-05	2.4E-05	5.9E-04	1.4E-04	2.6E-04	2.1E-06	2.0E-08	9.3E-06	4.1E-04
2230074110	3.1E-02	1.6E-01	2.5E-04	5.3E-04	7.0E-03	1.1E-03	5.7E-03	3.9E-05	1.5E-07	6.0E-05	6.9E-03
2230074130	1.5E-02	7.1E-02	9.8E-05	2.4E-04	3.5E-03	7.3E-04	3.0E-03	2.0E-05	1.6E-07	7.2E-05	3.8E-03
2230074150	7.0E-03	3.2E-02	4.4E-05	1.1E-04	1.6E-03	3.3E-04	1.4E-03	9.0E-06	7.1E-08	3.3E-05	1.7E-03
2230074170	2.7E-02	1.3E-01	1.7E-04	4.3E-04	6.2E-03	1.3E-03	5.3E-03	3.5E-05	2.8E-07	1.3E-04	6.8E-03
2230074190	7.4E-03	3.4E-02	4.7E-05	1.2E-04	1.7E-03	3.5E-04	1.4E-03	9.5E-06	7.5E-08	3.5E-05	1.8E-03
2230074210	2.9E-02	1.3E-01	1.8E-04	4.5E-04	6.5E-03	1.4E-03	5.6E-03	3.7E-05	2.9E-07	1.3E-04	7.1E-03
2230074230	5.0E-02	2.5E-01	3.4E-04	8.6E-04	1.1E-02	1.9E-03	1.1E-02	6.6E-05	3.7E-07	1.6E-04	1.3E-02
2230074250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230074270	1.2E-02	5.6E-02	7.6E-05	1.9E-04	2.8E-03	6.0E-04	2.4E-03	1.6E-05	1.4E-07	6.3E-05	3.1E-03
2230074290	1.4E-02	6.2E-02	8.3E-05	2.1E-04	3.1E-03	6.6E-04	2.6E-03	1.7E-05	1.5E-07	7.0E-05	3.4E-03
2230074310	7.3E-03	3.3E-02	4.5E-05	1.1E-04	1.7E-03	3.6E-04	1.4E-03	9.4E-06	8.0E-08	3.7E-05	1.8E-03
2230074330	6.1E-03	2.8E-02	3.7E-05	9.5E-05	1.4E-03	3.0E-04	1.2E-03	7.8E-06	6.7E-08	3.1E-05	1.5E-03
2230075110	2.5E-03	1.1E-02	1.2E-05	2.4E-05	5.1E-04	1.0E-04	4.2E-04	1.8E-06	8.2E-09	3.3E-06	5.3E-04
2230075130	1.1E-03	4.4E-03	4.3E-06	9.7E-06	2.1E-04	5.8E-05	1.8E-04	8.3E-07	8.8E-09	4.1E-06	2.5E-04
2230075150	4.9E-04	2.0E-03	1.9E-06	4.4E-06	9.7E-05	2.6E-05	8.3E-05	3.8E-07	4.0E-09	1.8E-06	1.1E-04

Table 5.6-69 Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 1											
SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230075170	1.9E-03	7.8E-03	7.6E-06	1.7E-05	3.8E-04	1.0E-04	3.2E-04	1.5E-06	1.6E-08	7.2E-06	4.3E-04
2230075190	5.2E-04	2.1E-03	2.0E-06	4.6E-06	1.0E-04	2.8E-05	8.8E-05	4.0E-07	4.2E-09	1.9E-06	1.2E-04
2230075210	2.0E-03	8.2E-03	7.9E-06	1.8E-05	4.0E-04	1.1E-04	3.4E-04	1.5E-06	1.6E-08	7.5E-06	4.6E-04
2230075230	4.0E-03	1.8E-02	1.7E-05	4.0E-05	7.7E-04	1.7E-04	7.9E-04	3.1E-06	1.9E-08	8.2E-06	9.8E-04
2230075250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230075270	8.7E-04	3.5E-03	3.4E-06	7.7E-06	1.7E-04	4.7E-05	1.5E-04	6.7E-07	7.7E-09	3.6E-06	2.0E-04
2230075290	9.5E-04	3.9E-03	3.7E-06	8.4E-06	1.9E-04	5.1E-05	1.6E-04	7.4E-07	8.4E-09	3.9E-06	2.2E-04
2230075310	5.1E-04	2.1E-03	2.0E-06	4.5E-06	1.0E-04	2.8E-05	8.7E-05	4.0E-07	4.5E-09	2.1E-06	1.2E-04
2230075330	4.2E-04	1.7E-03	1.6E-06	3.8E-06	8.4E-05	2.3E-05	7.2E-05	3.3E-07	3.7E-09	1.8E-06	9.7E-05
TOTAL	**22.63**	**4.24**	**0.08**	**0.05**	**0.87**	**0.40**	**0.13**	**0.00**	**0.00**	**0.07**	**0.61**

Table 5.6-70
Calendar Year 2008 Rate Per Vehicle Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001000	2.1E+01	3.2E-01	0.0E+00	2.4E-03	2.1E+00	6.4E-02	3.4E-02	1.2E-05	2.2E-06	1.6E-02	1.1E-01
2201020000	2.8E+01	5.1E-01	0.0E+00	3.5E-03	2.6E+00	1.0E-01	5.0E-02	1.8E-05	3.3E-06	2.6E-02	1.8E-01
2201040000	1.4E+01	2.6E-01	0.0E+00	1.8E-03	1.3E+00	5.4E-02	2.6E-02	9.4E-06	1.7E-06	1.3E-02	9.3E-02
2201070000	4.4E+00	6.9E-02	0.0E+00	4.5E-04	3.4E-01	2.6E-02	1.2E-02	3.7E-06	7.9E-07	6.4E-03	4.5E-02
2201080000	5.3E-01	4.3E-03	0.0E+00	4.5E-05	5.6E-02	3.7E-04	2.0E-04	2.1E-07	1.3E-08	9.5E-05	6.6E-04
2230001000	3.6E-03	4.3E-03	0.0E+00	5.0E-06	1.8E-03	1.6E-04	7.9E-05	3.5E-07	3.2E-07	4.1E-05	2.8E-04
2230060000	5.6E-02	6.9E-02	0.0E+00	8.9E-05	2.6E-02	6.2E-04	3.1E-04	6.3E-06	1.2E-06	1.6E-04	1.1E-03
2230071000	2.6E-02	3.3E-02	0.0E+00	4.2E-05	1.2E-02	2.7E-04	1.3E-04	3.0E-06	2.0E-07	6.8E-05	4.7E-04
2230072000	1.2E-01	1.5E-01	0.0E+00	2.0E-04	5.7E-02	1.3E-03	6.7E-04	1.4E-05	9.9E-07	3.4E-04	2.4E-03
2230073000	4.1E-02	2.0E-02	0.0E+00	2.4E-05	9.0E-03	5.6E-05	2.8E-05	1.7E-06	4.1E-08	1.5E-05	1.0E-04
2230074000	5.4E-02	2.7E-02	0.0E+00	3.3E-05	1.2E-02	6.9E-05	3.5E-05	2.3E-06	5.1E-08	1.9E-05	1.3E-04
2230075000	1.3E-02	5.7E-03	0.0E+00	8.8E-06	2.5E-03	1.9E-05	9.4E-06	6.1E-07	1.4E-08	5.0E-06	3.4E-05
TOTAL	**68.37**	**1.48**	**0.00**	**0.01**	**6.55**	**0.25**	**0.12**	**0.00**	**0.00**	**0.06**	**0.44**

Table 5.6-71
Calendar Year 2008 Rate Per Profile Emissions Inventory Summary by SCC for Episode 1

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201020000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201040000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201070000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201080000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230001000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230060000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230071000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230072000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230073000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230074000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230075000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOTAL	**0.00**	**0.00**	**0.00**	**0.00**	**0.13**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Table 5.6-72
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001110	8.0E-01	8.3E-02	5.0E-03	1.7E-03	2.1E-02	8.5E-03	1.9E-03	1.5E-05	1.3E-06	1.6E-03	1.2E-02
2201001130	4.2E-01	4.6E-02	2.7E-03	1.1E-03	1.5E-02	3.3E-03	7.3E-04	1.5E-05	9.0E-07	7.9E-04	4.8E-03
2201001150	1.9E-01	2.1E-02	1.2E-03	4.9E-04	6.8E-03	1.5E-03	3.3E-04	6.8E-06	4.1E-07	3.6E-04	2.2E-03
2201001170	7.4E-01	8.1E-02	4.7E-03	1.9E-03	2.7E-02	4.7E-03	1.0E-03	2.6E-05	1.6E-06	1.2E-03	7.0E-03
2201001190	2.0E-01	2.2E-02	1.3E-03	5.2E-04	7.2E-03	1.3E-03	2.8E-04	7.1E-06	4.3E-07	3.3E-04	1.9E-03
2201001210	7.7E-01	8.5E-02	4.9E-03	2.0E-03	2.8E-02	5.7E-03	1.3E-03	2.8E-05	1.7E-06	1.4E-03	8.3E-03
2201001230	1.1E+00	8.0E-02	4.2E-03	1.6E-03	2.1E-02	1.4E-02	3.0E-03	1.6E-05	1.9E-06	2.5E-03	1.9E-02
2201001250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201001270	3.4E-01	3.8E-02	2.2E-03	8.9E-04	1.2E-02	2.7E-03	5.9E-04	1.2E-05	7.4E-07	6.5E-04	3.9E-03
2201001290	3.8E-01	4.2E-02	2.5E-03	9.9E-04	1.4E-02	3.0E-03	6.6E-04	1.4E-05	8.3E-07	7.3E-04	4.4E-03
2201001310	2.0E-01	2.2E-02	1.3E-03	5.2E-04	7.3E-03	1.5E-03	3.3E-04	7.4E-06	4.4E-07	3.7E-04	2.2E-03
2201001330	1.7E-01	1.8E-02	1.1E-03	4.4E-04	6.1E-03	1.2E-03	2.6E-04	6.1E-06	3.6E-07	2.9E-04	1.7E-03
2201020110	1.6E+00	1.7E-01	5.6E-03	2.8E-03	3.8E-02	1.6E-02	1.2E-03	2.7E-05	1.3E-06	2.9E-03	2.0E-02
2201020130	7.6E-01	8.7E-02	2.8E-03	1.6E-03	2.6E-02	5.2E-03	4.1E-04	2.5E-05	1.1E-06	1.3E-03	6.9E-03
2201020150	3.4E-01	3.9E-02	1.3E-03	7.3E-04	1.2E-02	2.4E-03	1.9E-04	1.1E-05	4.9E-07	5.8E-04	3.1E-03
2201020170	1.3E+00	1.5E-01	4.9E-03	2.9E-03	4.7E-02	7.5E-03	6.0E-04	4.5E-05	1.9E-06	2.0E-03	1.0E-02
2201020190	3.6E-01	4.2E-02	1.3E-03	7.8E-04	1.3E-02	2.0E-03	1.6E-04	1.2E-05	5.2E-07	5.3E-04	2.7E-03
2201020210	1.4E+00	1.6E-01	5.1E-03	2.9E-03	4.8E-02	8.8E-03	7.0E-04	4.6E-05	2.0E-06	2.2E-03	1.2E-02
2201020230	2.0E+00	1.6E-01	4.8E-03	2.7E-03	4.0E-02	2.6E-02	1.9E-03	2.9E-05	1.7E-06	4.7E-03	3.3E-02
2201020250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201020270	6.1E-01	7.1E-02	2.3E-03	1.3E-03	2.2E-02	4.3E-03	3.4E-04	2.1E-05	9.0E-07	1.1E-03	5.7E-03
2201020290	6.8E-01	7.8E-02	2.5E-03	1.5E-03	2.4E-02	4.7E-03	3.7E-04	2.3E-05	9.9E-07	1.2E-03	6.2E-03
2201020310	3.6E-01	4.2E-02	1.3E-03	7.8E-04	1.3E-02	2.4E-03	1.9E-04	1.2E-05	5.3E-07	6.0E-04	3.2E-03
2201020330	3.0E-01	3.5E-02	1.1E-03	6.5E-04	1.1E-02	1.9E-03	1.5E-04	1.0E-05	4.4E-07	4.8E-04	2.5E-03
2201040110	7.8E-01	8.6E-02	2.8E-03	1.4E-03	1.9E-02	7.7E-03	5.8E-04	1.3E-05	5.9E-07	1.4E-03	9.7E-03
2201040130	3.8E-01	4.5E-02	1.5E-03	8.2E-04	1.3E-02	2.7E-03	2.1E-04	1.2E-05	4.9E-07	6.3E-04	3.6E-03
2201040150	1.7E-01	2.1E-02	6.6E-04	3.7E-04	5.8E-03	1.2E-03	9.6E-05	5.3E-06	2.2E-07	2.9E-04	1.6E-03
2201040170	6.7E-01	8.0E-02	2.6E-03	1.5E-03	2.3E-02	3.9E-03	3.1E-04	2.1E-05	8.7E-07	9.6E-04	5.2E-03
2201040190	1.8E-01	2.2E-02	7.0E-04	3.9E-04	6.1E-03	1.0E-03	8.3E-05	5.6E-06	2.4E-07	2.6E-04	1.4E-03
2201040210	6.8E-01	8.1E-02	2.6E-03	1.5E-03	2.3E-02	4.5E-03	3.5E-04	2.1E-05	8.8E-07	1.1E-03	6.0E-03
2201040230	1.0E+00	8.2E-02	2.5E-03	1.4E-03	2.0E-02	1.3E-02	1.0E-03	1.4E-05	8.3E-07	2.4E-03	1.7E-02
2201040250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201040270	3.1E-01	3.6E-02	1.2E-03	6.8E-04	1.1E-02	2.2E-03	1.7E-04	1.0E-05	4.5E-07	5.3E-04	2.9E-03

Table 5.6-72
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201040290	3.4E-01	4.0E-02	1.3E-03	7.5E-04	1.2E-02	2.4E-03	1.9E-04	1.1E-05	4.9E-07	5.9E-04	3.2E-03
2201040310	1.9E-01	2.2E-02	7.1E-04	4.1E-04	6.5E-03	1.2E-03	9.9E-05	6.3E-06	2.7E-07	3.1E-04	1.7E-03
2201040330	1.6E-01	1.8E-02	5.9E-04	3.4E-04	5.4E-03	9.7E-04	7.7E-05	5.2E-06	2.2E-07	2.4E-04	1.3E-03
2201070110	3.0E-01	3.0E-02	6.0E-04	3.5E-04	7.1E-03	3.4E-03	2.5E-04	4.1E-06	2.0E-07	6.0E-04	4.3E-03
2201070130	1.2E-01	1.3E-02	2.9E-04	1.8E-04	4.2E-03	9.7E-04	7.4E-05	2.9E-06	1.2E-07	2.0E-04	1.3E-03
2201070150	5.5E-02	5.9E-03	1.3E-04	8.2E-05	1.9E-03	4.4E-04	3.4E-05	1.3E-06	5.6E-08	9.2E-05	5.7E-04
2201070170	2.2E-01	2.3E-02	5.1E-04	3.2E-04	7.5E-03	1.4E-03	1.1E-04	5.2E-06	2.2E-07	3.0E-04	1.8E-03
2201070190	5.9E-02	6.2E-03	1.4E-04	8.6E-05	2.0E-03	3.8E-04	2.9E-05	1.4E-06	5.9E-08	8.2E-05	4.9E-04
2201070210	2.3E-01	2.4E-02	5.4E-04	3.3E-04	7.8E-03	1.7E-03	1.3E-04	5.5E-06	2.3E-07	3.5E-04	2.2E-03
2201070230	5.8E-01	4.1E-02	6.0E-04	4.3E-04	1.3E-02	5.7E-03	4.2E-04	5.9E-06	3.1E-07	1.0E-03	7.1E-03
2201070250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201070270	1.0E-01	1.1E-02	2.4E-04	1.5E-04	3.6E-03	7.7E-04	5.9E-05	2.7E-06	1.1E-07	1.7E-04	1.0E-03
2201070290	1.1E-01	1.2E-02	2.6E-04	1.7E-04	4.0E-03	8.5E-04	6.5E-05	2.9E-06	1.2E-07	1.8E-04	1.1E-03
2201070310	6.0E-02	6.2E-03	1.4E-04	9.0E-05	2.2E-03	4.3E-04	3.3E-05	1.6E-06	6.6E-08	9.5E-05	5.6E-04
2201070330	5.0E-02	5.2E-03	1.2E-04	7.5E-05	1.8E-03	3.3E-04	2.6E-05	1.3E-06	5.4E-08	7.4E-05	4.4E-04
2201080110	3.2E-01	7.9E-03	1.0E-04	7.4E-05	9.6E-03	1.2E-03	2.6E-04	4.2E-07	1.2E-07	2.0E-04	1.6E-03
2201080130	1.5E-01	3.4E-03	4.1E-05	3.7E-05	6.3E-03	4.0E-04	8.7E-05	2.3E-07	4.4E-08	6.8E-05	5.6E-04
2201080150	6.9E-02	1.5E-03	1.9E-05	1.7E-05	2.9E-03	1.8E-04	4.0E-05	1.1E-07	2.0E-08	3.1E-05	2.5E-04
2201080170	2.7E-01	6.0E-03	7.3E-05	6.5E-05	1.1E-02	5.7E-04	1.2E-04	4.1E-07	7.8E-08	9.8E-05	7.9E-04
2201080190	7.3E-02	1.6E-03	2.0E-05	1.8E-05	3.0E-03	1.5E-04	3.4E-05	1.1E-07	2.1E-08	2.7E-05	2.1E-04
2201080210	2.8E-01	6.3E-03	7.6E-05	6.9E-05	1.2E-02	6.9E-04	1.5E-04	4.3E-07	8.2E-08	1.2E-04	9.6E-04
2201080230	2.5E-01	6.2E-03	7.8E-05	6.2E-05	8.5E-03	1.9E-03	4.1E-04	3.6E-07	1.9E-07	3.2E-04	2.6E-03
2201080250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201080270	1.3E-01	2.9E-03	3.5E-05	3.2E-05	5.4E-03	3.4E-04	7.5E-05	2.0E-07	3.7E-08	5.9E-05	4.8E-04
2201080290	1.4E-01	3.2E-03	3.8E-05	3.5E-05	6.0E-03	3.8E-04	8.3E-05	2.2E-07	4.1E-08	6.5E-05	5.3E-04
2201080310	7.7E-02	1.7E-03	2.1E-05	1.9E-05	3.2E-03	1.9E-04	4.2E-05	1.2E-07	2.2E-08	3.3E-05	2.7E-04
2201080330	6.4E-02	1.4E-03	1.7E-05	1.6E-05	2.7E-03	1.5E-04	3.2E-05	9.7E-08	1.8E-08	2.6E-05	2.1E-04
2230001110	1.1E-04	6.7E-04	4.1E-06	6.3E-06	3.9E-05	4.9E-06	3.3E-05	4.7E-07	1.3E-07	2.0E-06	4.1E-05
2230001130	8.2E-05	4.4E-04	2.2E-06	3.7E-06	2.7E-05	4.0E-06	1.1E-05	3.0E-07	4.7E-08	1.8E-06	1.7E-05
2230001150	3.7E-05	2.0E-04	9.8E-07	1.7E-06	1.2E-05	1.8E-06	5.2E-06	1.3E-07	2.1E-08	8.0E-07	7.9E-06
2230001170	1.4E-04	7.7E-04	3.8E-06	6.6E-06	4.7E-05	7.0E-06	2.0E-05	5.2E-07	8.4E-08	3.1E-06	3.1E-05
2230001190	3.9E-05	2.1E-04	1.0E-06	1.8E-06	1.3E-05	1.9E-06	5.4E-06	1.4E-07	2.3E-08	8.5E-07	8.4E-06
2230001210	1.5E-04	8.1E-04	4.0E-06	6.9E-06	4.9E-05	7.3E-06	2.1E-05	5.5E-07	8.8E-08	3.3E-06	3.2E-05
2230001230	1.1E-04	6.1E-04	3.3E-06	5.8E-06	3.5E-05	6.0E-06	5.6E-05	4.4E-07	2.2E-07	2.5E-06	6.5E-05

Table 5.6-72
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230001250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230001270	7.3E-05	3.8E-04	1.8E-06	3.2E-06	2.3E-05	3.7E-06	9.1E-06	2.6E-07	3.8E-08	1.7E-06	1.5E-05
2230001290	8.0E-05	4.1E-04	2.0E-06	3.6E-06	2.6E-05	4.0E-06	1.0E-05	2.9E-07	4.2E-08	1.8E-06	1.6E-05
2230001310	4.3E-05	2.2E-04	1.1E-06	1.9E-06	1.4E-05	2.2E-06	5.4E-06	1.5E-07	2.2E-08	9.8E-07	8.7E-06
2230001330	3.6E-05	1.8E-04	9.0E-07	1.6E-06	1.1E-05	1.8E-06	4.4E-06	1.3E-07	1.9E-08	8.2E-07	7.2E-06
2230060110	1.6E-02	3.0E-02	2.0E-04	1.6E-04	4.6E-03	3.0E-04	1.6E-03	1.2E-05	6.5E-06	8.6E-05	2.0E-03
2230060130	1.1E-02	1.8E-02	9.3E-05	9.0E-05	3.0E-03	3.0E-04	7.9E-04	7.1E-06	3.2E-06	8.0E-05	1.2E-03
2230060150	4.8E-03	8.2E-03	4.2E-05	4.1E-05	1.3E-03	1.4E-04	3.6E-04	3.2E-06	1.5E-06	3.6E-05	5.4E-04
2230060170	1.9E-02	3.2E-02	1.6E-04	1.6E-04	5.2E-03	5.3E-04	1.4E-03	1.2E-05	5.7E-06	1.4E-04	2.1E-03
2230060190	5.1E-03	8.6E-03	4.5E-05	4.3E-05	1.4E-03	1.4E-04	3.8E-04	3.4E-06	1.5E-06	3.8E-05	5.7E-04
2230060210	2.0E-02	3.4E-02	1.7E-04	1.7E-04	5.5E-03	5.6E-04	1.5E-03	1.3E-05	6.0E-06	1.5E-04	2.2E-03
2230060230	1.7E-02	3.4E-02	1.9E-04	1.8E-04	4.9E-03	3.9E-04	1.9E-03	1.3E-05	7.6E-06	1.1E-04	2.4E-03
2230060250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230060270	9.4E-03	1.5E-02	7.6E-05	7.6E-05	2.6E-03	2.9E-04	6.5E-04	6.0E-06	2.6E-06	7.5E-05	1.0E-03
2230060290	1.0E-02	1.7E-02	8.3E-05	8.3E-05	2.8E-03	3.1E-04	7.1E-04	6.6E-06	2.9E-06	8.2E-05	1.1E-03
2230060310	5.6E-03	9.1E-03	4.5E-05	4.5E-05	1.5E-03	1.7E-04	3.8E-04	3.6E-06	1.5E-06	4.4E-05	6.0E-04
2230060330	4.6E-03	7.6E-03	3.7E-05	3.7E-05	1.3E-03	1.4E-04	3.2E-04	3.0E-06	1.3E-06	3.6E-05	5.0E-04
2230071110	7.4E-03	1.4E-02	9.3E-05	7.7E-05	2.2E-03	1.4E-04	7.4E-04	5.6E-06	1.1E-06	3.4E-05	9.2E-04
2230071130	5.0E-03	8.5E-03	4.4E-05	4.3E-05	1.4E-03	1.4E-04	3.7E-04	3.3E-06	5.6E-07	3.4E-05	5.4E-04
2230071150	2.3E-03	3.9E-03	2.0E-05	1.9E-05	6.4E-04	6.3E-05	1.7E-04	1.5E-06	2.5E-07	1.6E-05	2.5E-04
2230071170	8.9E-03	1.5E-02	7.8E-05	7.5E-05	2.5E-03	2.4E-04	6.5E-04	5.9E-06	9.9E-07	6.1E-05	9.6E-04
2230071190	2.4E-03	4.1E-03	2.1E-05	2.0E-05	6.7E-04	6.6E-05	1.8E-04	1.6E-06	2.7E-07	1.6E-05	2.6E-04
2230071210	9.4E-03	1.6E-02	8.2E-05	7.9E-05	2.6E-03	2.6E-04	6.8E-04	6.2E-06	1.0E-06	6.4E-05	1.0E-03
2230071230	7.9E-03	1.6E-02	8.8E-05	8.4E-05	2.3E-03	1.8E-04	8.6E-04	6.2E-06	1.3E-06	4.5E-05	1.1E-03
2230071250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230071270	4.5E-03	7.4E-03	3.6E-05	3.6E-05	1.2E-03	1.3E-04	3.0E-04	2.9E-06	4.7E-07	3.3E-05	4.7E-04
2230071290	5.0E-03	8.1E-03	4.0E-05	4.0E-05	1.4E-03	1.5E-04	3.3E-04	3.2E-06	5.1E-07	3.6E-05	5.2E-04
2230071310	2.7E-03	4.4E-03	2.1E-05	2.1E-05	7.3E-04	7.8E-05	1.8E-04	1.7E-06	2.7E-07	1.9E-05	2.8E-04
2230071330	2.2E-03	3.6E-03	1.8E-05	1.8E-05	6.1E-04	6.5E-05	1.5E-04	1.4E-06	2.3E-07	1.6E-05	2.3E-04
2230072110	3.5E-02	6.5E-02	4.3E-04	3.5E-04	1.0E-02	6.8E-04	3.6E-03	2.6E-05	5.4E-06	1.6E-04	4.4E-03
2230072130	2.3E-02	3.9E-02	2.0E-04	1.9E-04	6.5E-03	6.5E-04	1.7E-03	1.5E-05	2.6E-06	1.6E-04	2.6E-03
2230072150	1.1E-02	1.8E-02	9.1E-05	8.7E-05	2.9E-03	3.0E-04	7.8E-04	6.8E-06	1.2E-06	7.3E-05	1.2E-03
2230072170	4.1E-02	6.9E-02	3.5E-04	3.4E-04	1.1E-02	1.2E-03	3.0E-03	2.7E-05	4.7E-06	2.8E-04	4.5E-03
2230072190	1.1E-02	1.9E-02	9.6E-05	9.1E-05	3.1E-03	3.1E-04	8.3E-04	7.2E-06	1.3E-06	7.7E-05	1.2E-03

Table 5.6-72
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230072210	4.3E-02	7.2E-02	3.7E-04	3.5E-04	1.2E-02	1.2E-03	3.2E-03	2.8E-05	4.9E-06	3.0E-04	4.7E-03
2230072230	3.9E-02	7.7E-02	4.2E-04	4.0E-04	1.1E-02	9.0E-04	4.3E-03	3.0E-05	6.5E-06	2.2E-04	5.5E-03
2230072250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230072270	2.1E-02	3.3E-02	1.6E-04	1.6E-04	5.7E-03	6.2E-04	1.4E-03	1.3E-05	2.2E-06	1.5E-04	2.2E-03
2230072290	2.3E-02	3.7E-02	1.8E-04	1.8E-04	6.3E-03	6.8E-04	1.5E-03	1.4E-05	2.4E-06	1.7E-04	2.4E-03
2230072310	1.2E-02	2.0E-02	9.6E-05	9.5E-05	3.4E-03	3.7E-04	8.3E-04	7.6E-06	1.3E-06	9.0E-05	1.3E-03
2230072330	1.0E-02	1.6E-02	8.0E-05	7.9E-05	2.8E-03	3.0E-04	6.9E-04	6.3E-06	1.1E-06	7.5E-05	1.1E-03
2230073110	9.3E-03	4.0E-02	8.4E-05	1.4E-04	2.8E-03	5.5E-04	1.4E-03	1.0E-05	2.1E-06	1.2E-04	2.1E-03
2230073130	4.6E-03	1.9E-02	3.2E-05	6.3E-05	1.5E-03	3.4E-04	6.6E-04	5.2E-06	1.0E-06	8.1E-05	1.1E-03
2230073150	2.1E-03	8.5E-03	1.5E-05	2.8E-05	6.7E-04	1.6E-04	3.0E-04	2.4E-06	4.6E-07	3.7E-05	4.9E-04
2230073170	8.2E-03	3.3E-02	5.7E-05	1.1E-04	2.6E-03	6.0E-04	1.2E-03	9.2E-06	1.8E-06	1.4E-04	1.9E-03
2230073190	2.2E-03	9.0E-03	1.6E-05	3.0E-05	7.1E-04	1.6E-04	3.1E-04	2.5E-06	4.9E-07	3.9E-05	5.2E-04
2230073210	8.6E-03	3.5E-02	6.0E-05	1.2E-04	2.7E-03	6.3E-04	1.2E-03	9.6E-06	1.9E-06	1.5E-04	2.0E-03
2230073230	1.5E-02	7.1E-02	1.2E-04	2.4E-04	4.5E-03	8.9E-04	2.8E-03	1.9E-05	4.3E-06	2.1E-04	3.9E-03
2230073250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230073270	3.7E-03	1.5E-02	2.5E-05	5.0E-05	1.2E-03	2.8E-04	5.2E-04	4.2E-06	8.1E-07	6.8E-05	8.8E-04
2230073290	4.1E-03	1.7E-02	2.8E-05	5.5E-05	1.3E-03	3.1E-04	5.7E-04	4.6E-06	8.9E-07	7.5E-05	9.6E-04
2230073310	2.2E-03	8.9E-03	1.5E-05	2.9E-05	7.1E-04	1.7E-04	3.1E-04	2.5E-06	4.8E-07	4.0E-05	5.2E-04
2230073330	1.8E-03	7.4E-03	1.2E-05	2.4E-05	5.9E-04	1.4E-04	2.6E-04	2.1E-06	4.0E-07	3.3E-05	4.3E-04
2230074110	3.1E-02	1.6E-01	2.5E-04	5.3E-04	7.0E-03	1.1E-03	5.7E-03	3.9E-05	8.5E-06	2.7E-04	7.1E-03
2230074130	1.5E-02	7.1E-02	9.8E-05	2.5E-04	3.5E-03	7.3E-04	3.0E-03	2.0E-05	4.6E-06	2.1E-04	4.0E-03
2230074150	7.0E-03	3.2E-02	4.4E-05	1.1E-04	1.6E-03	3.3E-04	1.4E-03	9.0E-06	2.1E-06	9.3E-05	1.8E-03
2230074170	2.7E-02	1.3E-01	1.7E-04	4.3E-04	6.2E-03	1.3E-03	5.3E-03	3.5E-05	8.2E-06	3.6E-04	7.0E-03
2230074190	7.4E-03	3.4E-02	4.7E-05	1.2E-04	1.7E-03	3.5E-04	1.4E-03	9.5E-06	2.2E-06	9.9E-05	1.9E-03
2230074210	2.9E-02	1.3E-01	1.8E-04	4.5E-04	6.5E-03	1.4E-03	5.6E-03	3.7E-05	8.6E-06	3.8E-04	7.4E-03
2230074230	5.0E-02	2.5E-01	3.4E-04	8.6E-04	1.1E-02	1.9E-03	1.1E-02	6.6E-05	1.6E-05	5.3E-04	1.3E-02
2230074250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230074270	1.2E-02	5.6E-02	7.6E-05	1.9E-04	2.8E-03	6.0E-04	2.4E-03	1.6E-05	3.7E-06	1.7E-04	3.2E-03
2230074290	1.4E-02	6.2E-02	8.3E-05	2.1E-04	3.1E-03	6.6E-04	2.6E-03	1.7E-05	4.1E-06	1.9E-04	3.5E-03
2230074310	7.3E-03	3.3E-02	4.5E-05	1.1E-04	1.7E-03	3.6E-04	1.4E-03	9.4E-06	2.2E-06	1.0E-04	1.9E-03
2230074330	6.1E-03	2.8E-02	3.7E-05	9.5E-05	1.4E-03	3.0E-04	1.2E-03	7.8E-06	1.8E-06	8.5E-05	1.6E-03
2230075110	2.5E-03	1.1E-02	1.2E-05	2.4E-05	5.1E-04	1.1E-04	4.2E-04	1.8E-06	6.3E-07	2.2E-05	5.5E-04
2230075130	1.1E-03	4.4E-03	4.3E-06	9.7E-06	2.2E-04	5.8E-05	1.8E-04	8.3E-07	2.8E-07	1.4E-05	2.6E-04
2230075150	4.9E-04	2.0E-03	1.9E-06	4.4E-06	9.7E-05	2.6E-05	8.3E-05	3.8E-07	1.3E-07	6.5E-06	1.2E-04

Table 5.6-72
Calendar Year 2008 Rate Per Distance Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2230075170	1.9E-03	7.8E-03	7.6E-06	1.7E-05	3.8E-04	1.0E-04	3.2E-04	1.5E-06	4.9E-07	2.5E-05	4.5E-04
2230075190	5.2E-04	2.1E-03	2.1E-06	4.6E-06	1.0E-04	2.8E-05	8.8E-05	4.0E-07	1.3E-07	6.9E-06	1.2E-04
2230075210	2.0E-03	8.2E-03	8.0E-06	1.8E-05	4.0E-04	1.1E-04	3.4E-04	1.5E-06	5.2E-07	2.7E-05	4.8E-04
2230075230	4.0E-03	1.8E-02	1.7E-05	4.0E-05	7.7E-04	1.7E-04	7.9E-04	3.1E-06	1.2E-06	4.0E-05	1.0E-03
2230075250	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230075270	8.7E-04	3.5E-03	3.4E-06	7.7E-06	1.7E-04	4.7E-05	1.5E-04	6.7E-07	2.3E-07	1.2E-05	2.1E-04
2230075290	9.5E-04	3.8E-03	3.7E-06	8.4E-06	1.9E-04	5.1E-05	1.6E-04	7.4E-07	2.5E-07	1.3E-05	2.3E-04
2230075310	5.1E-04	2.1E-03	2.0E-06	4.5E-06	1.0E-04	2.8E-05	8.7E-05	4.0E-07	1.3E-07	7.0E-06	1.2E-04
2230075330	4.2E-04	1.7E-03	1.6E-06	3.8E-06	8.4E-05	2.3E-05	7.2E-05	3.3E-07	1.1E-07	5.8E-06	1.0E-04
TOTAL	**24.24**	**4.42**	**0.09**	**0.05**	**0.92**	**0.22**	**0.11**	**0.00**	**0.00**	**0.05**	**0.38**

Table 5.6-73
Calendar Year 2008 Rate Per Vehicle Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001000	1.6E+01	2.9E-01	0.0E+00	1.7E-03	1.3E+00	2.2E-02	1.2E-02	9.0E-06	2.3E-06	5.7E-03	4.0E-02
2201020000	2.2E+01	4.9E-01	0.0E+00	2.6E-03	1.7E+00	3.6E-02	1.7E-02	1.4E-05	3.4E-06	9.0E-03	6.2E-02
2201040000	1.2E+01	2.5E-01	0.0E+00	1.3E-03	8.9E-01	1.9E-02	8.9E-03	7.3E-06	1.8E-06	4.6E-03	3.2E-02
2201070000	3.8E+00	6.6E-02	0.0E+00	3.3E-04	2.4E-01	8.7E-03	4.2E-03	2.9E-06	8.3E-07	2.2E-03	1.5E-02
2201080000	4.3E-01	3.4E-03	0.0E+00	3.4E-05	3.5E-02	1.4E-04	7.3E-05	1.6E-07	1.4E-08	3.6E-05	2.5E-04
2230001000	2.3E-03	3.5E-03	0.0E+00	4.0E-06	1.4E-03	1.6E-04	7.9E-05	2.8E-07	3.2E-07	4.1E-05	2.8E-04
2230060000	3.7E-02	5.6E-02	0.0E+00	7.1E-05	2.0E-02	6.2E-04	3.1E-04	5.0E-06	1.2E-06	1.6E-04	1.1E-03
2230071000	1.8E-02	2.7E-02	0.0E+00	3.4E-05	9.4E-03	2.7E-04	1.3E-04	2.4E-06	2.0E-07	6.8E-05	4.7E-04
2230072000	8.2E-02	1.3E-01	0.0E+00	1.6E-04	4.4E-02	1.3E-03	6.7E-04	1.1E-05	9.9E-07	3.4E-04	2.4E-03
2230073000	3.3E-02	1.5E-02	0.0E+00	1.9E-05	6.9E-03	5.6E-05	2.8E-05	1.3E-06	4.2E-08	1.5E-05	1.0E-04
2230074000	4.4E-02	2.0E-02	0.0E+00	2.6E-05	9.1E-03	7.0E-05	3.5E-05	1.8E-06	5.1E-08	1.8E-05	1.2E-04
2230075000	1.1E-02	4.3E-03	0.0E+00	6.9E-06	1.9E-03	1.9E-05	9.4E-06	4.8E-07	1.4E-08	5.0E-06	3.4E-05
TOTAL	**54.89**	**1.35**	**0.00**	**0.01**	**4.30**	**0.09**	**0.04**	**0.00**	**0.00**	**0.02**	**0.15**

Table 5.6-74
Calendar Year 2008 Rate Per Profile Emissions Inventory Summary by SCC for Episode 2

SCC	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
2201001000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.9E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201020000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201040000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201070000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.7E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2201080000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230001000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230060000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230071000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230072000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230073000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230074000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
2230075000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TOTAL	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Table 5.6-75
Calendar Year 2008 On-Road Emissions Summary

Modeling Episode	Mode	CO (tons/day)	NO_x (tons/day)	NH_3 (tons/day)	SO_x (tons/day)	TOG (tons/day)	POC (tons/day)	PEC (tons/day)	PSO_4 (tons/day)	PNO_3 (tons/day)	PMFINE (tons/day)	$PM_{2.5}$ (tons/day)
Episode 1	RPD	2.3E+01	4.2E+00	8.4E-02	4.8E-02	8.7E-01	4.0E-01	1.3E-01	1.2E-03	3.2E-05	7.2E-02	6.1E-01
	RPV	6.8E+01	1.5E+00	0.0E+00	8.5E-03	6.5E+00	2.5E-01	1.2E-01	7.1E-05	1.1E-05	6.3E-02	4.4E-01
	RPP	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	TOTAL	**91.00**	**5.72**	**0.08**	**0.06**	**7.55**	**0.65**	**0.26**	**0.00**	**0.00**	**0.14**	**1.04**
Episode 2	RPD	2.4E+01	4.4E+00	9.1E-02	5.1E-02	9.2E-01	2.2E-01	1.1E-01	1.2E-03	1.9E-04	4.7E-02	3.8E-01
	RPV	5.5E+01	1.3E+00	0.0E+00	6.3E-03	4.3E+00	8.8E-02	4.4E-02	5.6E-05	1.1E-05	2.2E-02	1.5E-01
	RPP	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	TOTAL	**79.13**	**5.77**	**0.09**	**0.06**	**5.24**	**0.31**	**0.16**	**0.00**	**0.00**	**0.07**	**0.53**
E1 & E2 Weighted Average	RPD	2.3E+01	4.3E+00	8.8E-02	5.0E-02	8.9E-01	3.2E-01	1.2E-01	1.2E-03	1.1E-04	6.1E-02	5.0E-01
	RPV	6.2E+01	1.4E+00	0.0E+00	7.5E-03	5.5E+00	1.8E-01	8.7E-02	6.4E-05	1.1E-05	4.4E-02	3.1E-01
	RPP	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	TOTAL	**85.57**	**5.74**	**0.09**	**0.06**	**6.49**	**0.49**	**0.21**	**0.00**	**0.00**	**0.11**	**0.81**

NON-ROAD MOBILE SOURCES

Non-road sources encompass all mobile sources that are not on-road vehicles. They include recreational and commercial off-road vehicles and equipment as well as aircraft, locomotives, recreational pleasure craft (boats) and marine vessels.

This section of the appendix discusses the data and methodologies used to estimate emissions for the non-road source sector. (No information on either commercial marine or recreational vessel emissions is presented, as they do not operate in the arctic conditions experienced in the Fairbanks modeling domain during the winter.) The following sub-sections are organized based on the models or tools used to develop emission estimates for specific sources within the inventory sector.

NON-ROAD VEHICLES AND EQUIPMENT

EPA's latest NONROAD emissions model, NONROAD2008[88], 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);
- 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[89] (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 type of equipment in the list above, the NONROAD model estimates emission 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 some cases locally

[88] U.S. EPA NONROAD Model, Version 2008a, released July 2009.

[89] 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 lunder the "Aircraft" sub-section.

derived inputs which more accurately reflect the equipment population, growth rates, and wintertime activity levels in the Fairbanks area were substituted for EPA's default input values.

Calculation Methodology – The NONROAD model calculates emissions from each source category according to the following methodology:

$$\boldsymbol{Emissions = EF \times DF \times P \times LF \times Hours \times Units}$$

Where:

EF = emission factor in g/hp-hr;
DF = deterioration factor (dimensionless);
P = engine power in horsepower;
LF = load factor (dimensionless);
Hours = annual operating hours for each engine (unit); and
Units = total population of engines operating in a given year.

The above calculation yields emissions in grams per year, which the NONROAD model then converts to tons per year. For seasonal or daily emissions estimates, the calculated annual emissions for each source are then distributed over a given number of calendar months. For example, NONROAD assumes by default that all snowmobile activity takes place during the winter months, which are defined by the model to be December, January, and February. For this analysis, several modifications were made to equipment population growth rates, seasonal activity distribution, and annual operating hours and equipment populations. Summarized below are the specific modifications made to EPA's default NONROAD Model inputs.

Equipment Growth Rates – The NONROAD model predicts future equipment populations using national growth rates that have been determined using nationwide historical engine population estimates (i.e., for 1989 through 1996) from the Power Systems Research (PSR) PartsLink database. Given the relatively flat, and in some cases negative population growth predicted for Alaska's interior region, it is believed that the default NONROAD growth rates do not provide an accurate representation of equipment population growth trends in the 2010 through 2019 timeframe. For example, the default NONROAD growth factor results in a 2.8% annual increase in the snowmobile population in Fairbanks between 2010 and 2020—a figure that is twice as high as the annual human population growth rate predicted by the Alaska Department of Labor & Workforce Development for this area over the same period of time.

As shown in Table 5.6-76, a relatively flat annual growth rate of 1.4% for the total population of Alaska's interior region is predicted through 2020, which includes a negative growth rate in some of the smaller areas surrounding the Fairbanks nonattainment area. Therefore, to better reflect the 2015 and 2019 equipment populations in the Fairbanks nonattainment area, the human population projections for the individual interior regions shown in Table 1 were used as surrogate equipment population growth rates for all NONROAD equipment modeling performed for this inventory.

Table 5.6-76 Alaska Interior Region Human Population by Area (2010 to 2020)				
Interior Region	July 1, 2010	July 1, 2015	July 1, 2020	Annual Growth Rate (2010-2020)
Denali Borough	1,826	1,796	1,752	-0.41%
Fairbanks North Star Borough	98,000	105,928	113,275	1.56%
Southeast Fairbanks Census Area	7,055	7,635	8,141	1.54%
Yukon-Koyukuk Census Area	5,615	5,288	5,001	-1.09%
Interior Region Total	112,496	120,647	128,169	1.39%

<u>Modifications to Snowmobile Inputs</u> – Because the overwhelming majority of the wintertime non-road emissions in the Fairbanks area are associated with snowmobile activity, it was important to utilize all available FNSB-specific input NONROAD modeling parameters for this equipment category. This analysis was performed using the following modifications to NONROAD's snowmobile inputs:

Snowmobile Populations – The current version of EPA's NONROAD model predicts a calendar year (CY) 2010 population of 12,193 snowmobiles in the Borough, which is very close to the 12,420 snowmobiles registered in FNSB for that same year.[90] However, snowmobile populations in the areas surrounding FNSB did not approximate DMV registration data as closely as in the Borough, as shown in Table 5.6-77 below. Consequently, the CY2010 DMV registration totals shown below were substituted for the default NONROAD snowmobile population.

Table 5.6-77 Alaska Interior Region Snowmobile Population by Area for CY 2010		
Interior Region	NONROAD Default Population	Alaska DMV Registrations
Denali Borough	168	410
Fairbanks North Star Borough	12,193	12,420
Southeast Fairbanks Census Area	518	1,115
Yukon-Koyukuk Census Area	567	808

Snowmobile Activity – Snowmobile use inside the urban nonattainment area is largely banned because of public safety ordinances that prohibit their use on public trails and on public

[90] Data obtained from the Alaska Division of Motor Vehicles (DMV).

roadways. To address the fact that most snowmobile activity takes place outside the nonattainment area, the NONROAD default annual activity rate of 57 hours/year/unit was applied to only half of the FNSB snowmobile population. In addition, to account for loading, unloading, and maintenance activities that presumably take place inside the nonattainment area, an additional 1 hour/year/unit of snowmobile activity was assumed for the entire snowmobile population. All other snowmobile activity is assumed to occur in areas outside the Borough and/or the nonattainment area.

Snow Blowers – For purposes of this analysis, emissions from this equipment source were assumed to be zero. $PM_{2.5}$ violations (and consequently, $PM_{2.5}$ design days) always occur when there is a strong inversion layer over the region, rather than during periods of snow activity when snow blowers are typically used. Therefore, since snow blowers are not typically in use on the $PM_{2.5}$ design day, we have discounted their emissions from this analysis.

Nonexistent Wintertime Activity – Due to the severe outdoor weather conditions present in Fairbanks during the winter months, FNSB staff has 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 have been removed from this analysis:

- 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).

Selected equipment from the following categories was retained, as follows:

- Construction and Mining – Graders, off-highway trucks, rubber tire dozers, and rubber tire loaders were retained to represent snow removal equipment activity.

- Industrial Equipment – Equipment that primarily operates indoors (such as forklifts, aerial lifts, and terminal tractors) was retained.

Equipment Not Included in NONROAD Model – Discussions with FNSB staff[91] indicate that indirect-fired temporary Diesel and propane heaters are commonly used in FNSB in connection with any indoor construction or repair work performed during the winter months. These heaters are in constant use (24 hours/day, 7 days/week) during the six month FNSB winter period while regular indoor heating systems at construction sites are non-operational. Because these heaters

[91] Personal communication between Glenn Miller (FNSB) and Bob Dulla (Sierra Research), 3/4/2013.

are not included on the NONROAD model equipment list, we have calculated emissions from this source separately, as shown below in Table 5.6-78 and Table 5.6-79.

FNSB staff has estimated that a total of 30 heaters (10 small propane and 20 large Diesel units) operate continually at various construction sites during the winter months. Unit heating capacity was obtained from vendor specifications.[92]

Table 5.6-78
Emissions from Indirect-Fired Temporary Heaters - Diesel

# units	Unit Heating Capacity (Btu/hr)	Fuel Heat Value (Btu/gallon)	Emission Factors (lb/1000 gallons) (AP-42, Table 1.3-1)				
			NO_x	CO	PM	TOC	SO_x
20	2,000,000	138,500	10	5	2	0.556	0.61
Tons/Year from All Units:			6.3	3.2	1.3	0.35	0.39

Table 5.6-79
Emissions from Indirect-Fired Temporary Heaters - Propane

# units	Unit Heating Capacity (Btu/hr)	Fuel Heat Value (Btu/ft^3)	Emission Factors (lb/10^6 ft^3) (AP-42, Table 4-1)				
			NOx	CO	PM	TOC	SO_x
10	450,000	2,500	100	21	4.5	5.8	0.426
Tons/Year from All Units:			0.39	0.08	0.02	0.02	0.002

These indirect-fired temporary heater emissions were added to the inventory and assumed to occur only during winter months. The Source Classification Codes (SCCs) assigned to these heaters were as follows:

- SCC 2270002000 – Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Total; and
- SCC 2267002000 – Mobile Sources, LPG, Construction and Mining Equipment, All.

Fuel and Temperature Inputs – NONROAD modeling runs were executed for the four counties within the $PM_{2.5}$ modeling domain:

[92] *http://www.etopp.com/indirect-fired-temporary-heaters.html*.

1. Fairbanks North Star Borough (FNSB);
2. Denali Borough;
3. Southeast Fairbanks Census Area; and
4. Yukon-Koyukuk Census Area.

For each of these counties, calendar year 2008, 2015 and 2019 wintertime fuel parameters for both gasoline and diesel fueled equipment were set to correspond to the levels EPA has assumed in the MOVES model for FNSB. This reflects the fact that mobile source fuel in interior Alaska is refined locally. So the same gasoline and diesel refinery blends are used in both on-road and non-road sources in Fairbanks. Table 5.6-80 below shows both the NONROAD default values and the FNSB fuel parameters and temperature inputs used in this NONROAD modeling effort.

Table 5.6-80
NONROAD Modeling Wintertime Fuel and Temperature Inputs

Fuel Parameter	NONROAD Default	CY 2008	CY2015	CY 2019
Gasoline RVP	8.0	14.7		
Gas Oxygen Weight (%)	2.44	0.0		
Gas Sulfur (%)	0.0339	0.00688	0.0028	
Diesel Sulfur (%)	0.0351	0.0043	0.0011	
Marine Diesel Sulfur (%)	0.0435	0.0043	0.0011	
CNG/LPG Sulfur (%)	0.003	0.003		
Stage II Control (%)	0	0		
EtOH Blend Market (%)	75.1	0		
EtOH Volume (%)	9.3	0		
Minimum Temperature (°F)	-	-15.7		
Maximum Temperature (°F)	-	4.0		
Average Temperature (°F)	-	-6.0		

Annual and Seasonal Model Runs – As explained earlier, the NONROAD model was executed to generate average winter season emissions, overriding seasonal variation defaults in the model where local data were available. The winter season emissions were tabulated into as winter daily averages over model runs for the six winter months (October through March). In addition, annual (12-month) model runs were also executed because of the way in which emissions must be formatted for input to the SMOKE emissions processing model to support the attainment modeling. For non-road sources, SMOKE requires annual average emission inputs (in tons/year) coupled with monthly temporal allocation factors. These temporal allocations were developed from the winter season average and annual emission estimates. Although non-road sources are not the dominant sector for direct $PM_{2.5}$ and precursor emissions in the modeling domain during the winter non-attainment season, several of the sources (e.g., snowmobiles) exhibit strong seasonal activity variations which needed to be accounted for in the inventory workflow feeding the attainment modeling.

Summary of Emissions – Calendar year 2008 NONROAD model emissions tabulated by equipment category totaled across the four-county modeling domain are presented below in Table 5.6-81. (These tabulations also include emissions from temporary heaters which were added to the NONROAD model outputs as noted earlier.)

Table 5.6-81
Calendar Year 2008 NONROAD Model Emissions by Equipment Category

Equipment Category	Grid 3 Domain NONROAD Model Emissions (tons/year)						
	VOC	CO	NO_x	SO_x	PM10-PRI	PM25-PRI	NH3
Recreational Equipment	2,072.2	5,153.1	23.7	1.4	48.5	44.7	0.5
Construction & Mining Equipment	40.8	333.5	256.7	1.2	23.3	22.5	0.2
Industrial Equipment	4.9	86.3	25.0	0.1	1.5	1.4	1.4
Lawn & Garden Equipment (Res)	90.6	1,080.7	11.1	0.1	1.7	1.5	0.0
Lawn & Garden Equipment (Com)	6.4	90.6	1.4	0.0	0.3	0.3	0.0
Agricultural Equipment	3.0	24.5	24.1	0.1	2.3	2.3	0.1
Commercial Equipment	30.7	532.5	20.7	0.1	1.7	1.7	1.2
Logging Equipment	2.6	26.0	6.7	0.0	0.7	0.6	0.0
Pleasure Craft	319.1	948.8	44.8	0.3	5.2	4.8	0.1
Railroad Equipment	0.2	2.3	1.0	0.0	0.1	0.1	0.0
TOTALS	**2,570.4**	**8,278.4**	**415.3**	**3.2**	**85.4**	**80.0**	**3.5**

Attachment D provides a detailed listing of calendar year 2008 NONROAD outputs by individual SCC for each of the four counties within the modeling domain. It also includes the SCC-specific winter season allocation factors used in the attainment modeling to apportion annual emissions to episodic wintertime daily averages.

Spatial Allocation – In the absence of well-developed, source-specific surrogates for Alaska[93], NONROAD outputs were spatially allocated to individual grid cells in the modeling domain based on apportionment factors developed from block-level occupied household counts obtained from the 2010 U.S. Census. It was assumed that relative density of occupied households was a reasonable surrogate for allocating all SCC-specific categories from the NONROAD modeling runs with the exception of snowmobiles, which used a modified version of the Occupied

[93] EPA has developed a detailed set of SMOKE-ready surrogate files for use in spatial allocation down to 4 km grid cell sizes as described here: http://www.epa.gov/ttn/chief/emch/spatial/index.html. However, although the domain over which these surrogates were developed convers much of North American, is does not extend to Alaska.

Household surrogate based on allocations of snowmobile activity inside and outside the $PM_{2.5}$ non-attainment area that were discussed earlier in this sub-section.

Locomotives

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

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 2010) was obtained from the Alaska Railroad Corporation[94] (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[95] to estimate rail emissions within the emissions inventory.

Table 5.6-82 lists the train activity data by line segment and switching yard supplied by ARRC. Conversations with ARRC indicated that these November 2010 estimates were reasonably representative of the broader six month winter season.

Table 5.6-82
Winter 2010 Train Activity by Line Segment and Yard

Line Segment or Switching Yard	November Avg. (# of trains/day) [1]	Hours of Operation	Miles (per train)	Locomotives (per train)[2]	Fuel Cons. (gal/train)[3]
Healy to Fairbanks	4	0001 - 1800	108	5	1512
Fairbanks to North Pole	2	2100 - 0800	17	4	190
North Pole to Eielson	1	0800 - 1600	12	2	67
Eielson to Ft. Greely	Zero	n/a	80		Zero
Fairbanks Yard	2	24 Hours	10	2	56
Eielson Yard[4]	1	8 Hours	5	1	14

Notes:
[1] The Healy to Fairbanks segment is based on average number of trains run in a week divided by seven days. The North Pole to Eielson value is an average number. ARRC does not go to Eielson from Fairbanks every day.
[2] Locomotive numbers from Fairbanks Operations Chief
[3] Fuel consumption from Mechanical Manager (~2.8 gallons/mi at average throttle speed)
[4] Eielson AFB has their own yard locomotives

Source: Alaska Railroad Corporation.

[94] Email from Greg Lotakis, Alaska Railroad Corporation to Bob Dulla, Sierra Research, May 10, 2011.
[95] "Emission Factors for Locomotives," U.S. Environmental Protection Agency, Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

ARRC staff also indicated that train activity in this part of the state has been fairly flat from year to year. Thus, these 2010 estimates were assumed to be reasonably representative of base year 2008 activity. Given the modest rate of future economic growth forecasted for the Alaskan interior, the train activity shown in Table 5.6-82 was assumed constant in future year inventories through 2019.

These train activity data were combined with EPA-published locomotive emission factors which are presented in Table 5.6-83. In the absence of detailed locomotive age data from ARRC, the calendar year specific emission factors shown in Table 5.6-83 were based on Tables 5 through 7 of the cited EPA locomotives publication.

Table 5.6-83
EPA Emission Factors (g/gal) for Locomotives by Calendar Year and Activity Type

Calendar Year	Activity Type	HC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2
2008	Large Line-Haul	9.0	26.6	169	5.1	4.9	3.13
2008	Large Switch	14.5	38.1	243	5.5	5.3	3.13
2015	Large Line-Haul	5.7	26.6	129	3.4	3.3	0.09
2015	Large Switch	12.6	38.1	215	4.8	4.7	0.09
2019	Large Line-Haul	3.9	26.6	103	2.5	2.4	0.09
2019	Large Switch	11.4	38.1	200	4.4	4.3	0.09

Source: U.S. Environmental Protection Agency, EPA-420-F-09-025.

Emission factors for CO are constant across calendar year since the CO standard is the same across all locomotive Tier categories. Per EPA guidance, $PM_{2.5}$ emission factors were scaled from those for PM_{10} using a 97% scaling factor. SO_2 emission factors were also developed based on EPA guidance using estimates of diesel fuel density (3200 g/gal), sulfur to SO_2 conversion rate (97.5%) and fuel sulfur (500 ppm in 2008, 15 ppm in 2012 and later from Alaska Ultra Low Sulfur Diesel[96] phase in).

Table 5.6-84 through Table 5.6-86 show the locomotive emissions calculated by combining activity and emission factor data in the preceding two tables, multiplying fuel consumption by the gram per gallon emission factors.

96 https://dec.alaska.gov/air/anpms/ulsd/ulsdhome.htm

Table 5.6-84 Calendar Year 2008 Locomotive Emissions by Line Segment and Yard						
Line Segment or Switching Yard	HC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2
Healy to Fairbanks (lb/day)	120.00	354.67	2253.38	68.00	65.96	41.73
Fairbanks to North Pole (lb/day)	7.54	22.28	141.58	4.27	4.14	2.62
North Pole to Eielson (lb/day)	1.33	3.93	24.96	0.75	0.73	0.46
Eielson to Ft. Greely (lb/day)	0	0	0	0	0	0
Fairbanks Yard (lb/day)	3.58	9.41	60.00	1.36	1.32	0.77
Eielson Yard (lb/day)	0.45	1.18	7.50	0.17	0.16	0.10
Total Locomotive Emissions (lb/day)	132.90	391.47	2487.43	74.56	72.32	45.68
Total Locomotive Emissions (tons/year)	**24.25**	**71.44**	**453.96**	**13.61**	**13.20**	**8.34**

Table 5.6-85 Calendar Year 2015 Locomotive Emissions by Line Segment and Yard						
Line Segment or Switching Yard	HC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2
Healy to Fairbanks (lb/day)	76.00	354.67	1720.04	45.33	43.97	1.25
Fairbanks to North Pole (lb/day)	4.78	22.28	108.07	2.85	2.76	0.08
North Pole to Eielson (lb/day)	0.84	3.93	19.05	0.50	0.49	0.01
Eielson to Ft. Greely (lb/day)	0	0	0	0	0	0
Fairbanks Yard (lb/day)	3.11	9.41	53.09	1.19	1.15	0.02
Eielson Yard (lb/day)	0.39	1.18	6.64	0.15	0.14	0.00
Total Locomotive Emissions (lb/day)	85.12	391.47	1906.89	50.02	48.52	1.37
Total Locomotive Emissions (tons/year)	**15.53**	**71.44**	**348.01**	**9.13**	**8.85**	**0.25**

Table 5.6-86 Calendar Year 2019 Locomotive Emissions by Line Segment and Yard						
Line Segment or Switching Yard	HC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2
Healy to Fairbanks (lb/day)	52.00	354.67	1373.36	33.33	32.33	1.25
Fairbanks to North Pole (lb/day)	3.27	22.28	86.29	2.09	2.03	0.08
North Pole to Eielson (lb/day)	0.58	3.93	15.21	0.37	0.36	0.01
Eielson to Ft. Greely (lb/day)	0	0	0	0	0	0
Fairbanks Yard (lb/day)	2.81	9.41	49.38	1.09	1.05	0.02
Eielson Yard (lb/day)	0.35	1.18	6.17	0.14	0.13	0.00
Total Locomotive Emissions (lb/day)	59.01	391.47	1530.42	37.02	35.91	1.37
Total Locomotive Emissions (tons/year)	**10.77**	**71.44**	**279.30**	**6.76**	**6.55**	**0.25**

Spatial Allocation – Line-haul locomotive emissions over each of the rail segments listed in the preceding tables were spatially allocated to individual grid cells in the modeling domain using GIS software and a statewide rail line shapefile developed by the U.S. Department of Transportation. The allocations assumed a constant line-haul speed and thus were proportional to the lineal track length within each grid cell.

Yard-switching emissions were allocated to specific grid cells that encompassed the Fairbanks and Eielson rail yards using estimated apportionment factors that corresponded to the amounts of switching track lines within each cell.

AIRCRAFT

Emissions were estimated from aircraft operations at three regional airfields within the modeling domain: 1) Fairbanks International Airport (FAI); 2) Fort Wainwright Army Post[97] (FBK); and 3) Eielson Air Force Base (EIL). The aircraft emissions were developed using the Federal Aviation Administration's (FAA) Emission and Dispersion Modeling System (EDMS). EDMS 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. At the time the analysis was performed, EDMS 5.1.3 was the latest available version.

EDMS Methodology Summary - The EDMS 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 EDMS 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 vertical grid structure established for the Fairbanks $PM_{2.5}$ attainment modeling consists of 38 vertical layers ranging between ground level and 100,000 feet as shown in Table 5.6-87. The current version of EDMS allows the user to vary the mixing height over a range from 1,000 feet to a maximum of 10,000 feet. Thus, the tan-shaded layers (1 through 21) in Table 5.6-87 represent those for which EDMS emissions were assigned or distributed as described below.

Emissions associated with aircraft start up, taxi in or out, and take off, were assigned to Layer 2 (approximately 13 feet above ground level) to reflect average engine heights above ground. GSE and APU emissions were assigned to Layer 1. Climb out and approach emissions were ascribed proportionately between layers 2 and 11 (form 13 to approximately 1,300 feet) based upon the relative size of the distance between layer boundaries. Separate EDMS runs were made for each of the remaining 10 layers (Layers 12-21) with boundaries between 1,000 and 10,000 feet.

All EDMS runs assumed the minimum temperature allowable in default mode of -9.08°C (15.7°F). The following sub-sections separately describe the data sources, assumptions and methods used to generate EDMS-based aircraft emission estimates for each airfield.

[97] Formerly Ladd Air Force Base.

Table 5.6-87 Vertical Layer Boundaries Included in the Emissions Analysis					
Layer	Meters	Feet	Layer	Meters	Feet
1	0	0	20	2,408.84	7,903.01
2	4.00	13.13	21	2,922.27	9,587.47
3	8.00	26.26	22	3,470.92	11,387.50
4	12.81	42.03	23	4,059.98	13,320.13
5	23.63	77.54	24	4,695.90	15,406.45
6	46.94	153.99	25	5,386.76	17,673.05
7	67.89	222.73	26	6,142.97	20,154.05
8	112.79	370.05	27	6,978.19	22,894.28
9	177.96	583.87	28	7,910.89	25,954.32
10	276.73	907.91	29	8,966.86	29,418.78
11	410.35	1,346.28	30	10,126.79	33,224.30
12	546.23	1,792.09	31	11,416.93	37,457.05
13	684.46	2,245.61	32	12,875.50	42,242.38
14	825.13	2,707.10	33	14,512.04	47,611.59
15	968.31	3,176.85	34	16,445.80	53,955.93
16	1,150.96	3,776.12	35	18,747.26	61,506.62
17	1,375.80	4,513.78	36	21,744.80	71,341.08
18	1,646.36	5,401.43	37	25,751.01	84,484.76
19	1,987.69	6,521.28	38	32,139.07	105,442.93

Fairbanks International Airport - Fairbanks International Airport is a state-owned public-use airport located three miles (5 km) southwest of the central business district of Fairbanks in the North Star Borough of Alaska. Given the fact that FAI is positioned only 9.5 hours from 90% of the northern industrialized hemisphere and considering that the airport is open 24 hours a day (including holidays), FAI is convenient for servicing cargo airlines as a refueling stop for aircraft on trans-polar routes. FAI is also served by a number of passenger airlines.

Annual LTOs for FAI in 2008, 25,607, were obtained from the Alaska International Airport System (AIAS)[98]. However, these AIAS data did not include the distribution of LTOs by aircraft type. The LTO distribution by aircraft types was derived from the FAI Statistics System.[99] A report generated for January of 2011 included the activity of 45 air carriers utilizing 39 different types of aircraft. 92% of the reported LTOs were attributable to aircraft types that were included in the EDMS model. The remaining 8% of the LTOs were either ascribed to similar aircraft with respect to manufacturer, size and purpose, or proportionately distributed among those aircraft types present in the model. Table 5.6-88 presents the distribution of 2008 LTOs by airframe for FAI used in the modeling.

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[98] Alaska International Airport System – Statistics, Alaska Department of Transportation and Public Facilities, http://dot.alaska.gov/aias/stat2557scascca.shtml.
[99] http://dot.alaska.gov/faiiap/index.shtml.

Table 5.6-88
2008 LTOs by Aircraft Type for Fairbanks International Airport (FAI)

Airframe	LTOs	Airframe	LTOs
Boeing 737-400	3,075	Douglas DC-6	891
Boeing 737-700	353	Dehavilland Q400	17
Boeing 737-800	1,882	Bombardier DHC-8	1,764
Boeing 737-900	554	Embraer EM-120	168
Boeing 747-200	67	Embraer EJR-135	17
Boeing 747-400	50	Gulfstream 450	17
Boeing 767-300	34	Gulfstream 550	50
ATR-72	319	Gulfstream IV	34
Beechcraft-1900C	1,680	Gulfstream V	101
Beechcraft-1900D	706	Hawker HS-125 900XP	34
Boeing BBJ	34	Lockheed L-100-30	118
Bombardier Global Express	34	Lear-35A	403
Cessna 206	907	Piper PA-31	7,511
Cessna 208	3,730	Piper PC-12	50
Cessna Citation 550	17	Piper Lance PA32R	756
Bombardier Challenger 604	84	Fairchild SA-227	17
Dassault Falcon 20	50	Short Sky Van	84

In default mode, EDMS automatically assigns GSE and auxiliary power units (APU) to each LTO based upon airframe type. GSE include air conditioning units, air starts, aircraft tractors, baggage tractors, belt loaders, bobtails, cabin service trucks, cargo loaders, carts, catering trucks, deicers, fork lifts, fuel trucks, generators, ground power units, hydrant carts, lavatory trucks, lifts, passenger stands, service trucks, sweepers, water service trucks, and any other vehicles or equipment that tend to the aircraft while at the gate. Although APUs are most often on-board generators that provide electrical power to the aircraft while its engines are shut down, many aircraft utilize external generators. For purposes of this analysis, the EDMS defaults for GSE and APU age distribution, motive power and operating time per LTO were used. All GSE and APUs emissions were assigned to ground level as noted earlier.

The EDMS estimated 2008 emission inventory for FAI is presented in Table 5.6-89 below.

Table 5.6-89
2008 FAI Emissions Inventory by Source Category (Metric Tons per Day)

Source	CO_2	CO	THC	VOC	TOG	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	76.439	1.934	0.118	0.115	0.125	0.255	0.031	0.002	0.002
APU	-	0.010	0.001	0.001	0.001	0.005	0.001	0.001	0.001
GSE	-	0.328	-	0.011	0.012	0.036	0.001	0.001	0.001
Totals	**76.439**	**2.272**	**0.118**	**0.127**	**0.138**	**0.296**	**0.033**	**0.004**	**0.004**

Fort Wainwright/LADD Army Airfield - Fort Wainwright (FBK) is located adjacent to Fairbanks in the interior of Alaska in the North Star Borough about 365 miles north of Anchorage. Information regarding 2008 LTOs was obtained from FBK in the form of monthly average flights by group. Table 5.6-90 below presents these data. (Annual LTOs were developed by multiplying the monthly averages shown in Table 5.6-90 by a factor of 12.)

Table 5.6-90
Fort Wainwright Monthly Average Flights by Group

Group	Base Year
Military/Local	832
Military/Transient	195
General Aviation / Local	486
General Aviation / Transient	570
Monthly Total	**2,083**

Summaries of the type of aircraft in each of these groups are provided below:

- *Military/Local* - denotes activity by Army-owned aircraft stationed at Ladd Army Airfield which are all rotary-wing aircraft; CH-47 Chinook, UH-60 Blackhawks and OH-58 Kiowa Warriors. The monthly LTOs for this group were distributed according to the proportion of available aircraft.

- *Military/Transient* - reflects activity by military aircraft that utilize the airspace/airfield that are not stationed at Ladd Army Airfield. The aircraft inventory includes the A-10 Warthog, C-12 Huron, C-130 Hercules, C-17 Globe Master, F-16 Falcon and KC-135 Strato-Tanker. The monthly LTO for this group were assumed to be evenly distributed across the available airframes.

- *General Aviation/Local* - represents activity by Bureau of Land Management (BLM) owned aircraft stationed at Ladd Army Airfield. The aircraft mix in this group includes the Bell 212, Euro-Copter AS-350, Canadair CL-215 Scooper, CASA C-212 Avio-car, Cessna 206 Sky Wagon, Dornier 228 and Short Sherpa. The LTOs for this group were evenly distributed across all airframes.

- *General Aviation/Transient* - denotes activity by non-military aircraft not stationed at Ladd Army Airfield. The mix of aircraft in this group includes the Beech King Air 350, Boeing 737, Citation Cessna 552, Gulfstream Jet V, and Bell 206 Jet-Ranger.

As was the case with FAI, some of the aircraft in use at FBK were not found in the EDMS database. In these instances, alternative airframes were selected according to similarity, or the LTOs associated with those missing aircraft were proportionately distributed among the remainder of the fleet. The LTOs by aircraft used in the FBK modeling are presented in Table 5.6-91.

Table 5.6-91
2008 LTOs by Aircraft Type for Fort Wainwright/LADD Army Airfield (FBK)

Airframe	LTOs	Airframe	LTOs
Bell 206	2,876	Dornier 228	1,166
Boeing 737	1,710	A-10 Thunderbolt II	390
C-17 Globe Master	390	Gulfstream Jet V	1,710
CH-46 Sea Knight	3,328	OH-6 Cayuse	3,328
KC-135 Strato-Tanker	390	F-16 Falcon	390
CL-415	1,166	C-12 Huron	390
CASA C-212	1,166	UH-60 Blackhawk	3,328
Cessna 206 Sky Wagon	1,166	C-130 Hercules	390
Citation Cessna 552	1,710	**Total**	**24,996**

GSE and APU assignment and emissions were modeled using the EDMS defaults. The resulting inventory for FBK is summarized in Table 5.6-92 as follows.

Table 5.6-92
2008 FBK Emissions Inventory by Source Category (Metric Tons per Day)

Source	CO_2	CO	THC	VOC	TOG	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	77.839	0.506	0.115	0.132	0.133	0.287	0.032	0.004	0.004
APU	0.000	0.007	0.000	0.000	0.000	0.004	0.001	0.001	0.001
GSE	0.000	0.007	0.000	0.000	0.000	0.004	0.001	0.001	0.001
Totals	**77.839**	**0.625**	**0.115**	**0.137**	**0.139**	**0.318**	**0.033**	**0.005**	**0.005**

Eielson Air Force Base - Eielson Air Force Base (EIL) is located approximately 26 miles (42 km) southeast of Fairbanks, Alaska in central Alaska's Fairbanks-North Star Borough. North Pole is the nearest community to the base, located nine miles away. Established in 1943 as Mile 26 Satellite Field, Eielson is home to the 354th Fighter Wing which is part of the Eleventh Air Force (11 AF) of Pacific Air Forces (PACAF).

Eielson played an important role because of its strategic location. Aircraft movement information including take off, landings, touch-and-go, low approach, or aircraft passing though EIL airspace were provided by AFB personnel for February of 2008. It was estimated that some 1,100 aircraft movements per month (13,200 annual LTOs) were attributable to AFB operations with an approximately 60% / 40% military / civilian distribution.

The airframes assigned to EIL include the A-10 Thunderbolt II, C-123, F-4 Phantom II, F-16 Fighting Falcon, KC-135 Strato-Tanker, and the OV-10 Bronco. Lacking aircraft specific LTO information, it was assumed that each aircraft was equally likely to have contributed to overall emissions for the purposes of this analysis. Civilian traffic was attributed to the Piper PA-31 as the most frequent flyer found in the analysis of FAI. The assumed LTOs by aircraft type for EIL are included in Table 5.6-93 below.

Table 5.6-93
2008 LTOs by Aircraft Type for Eielson Air Force Base (EIL)

Airframe	LTOs	Airframe	LTOs
KC-135 Strato-Tanker	1,056	Rockwell OV-10 Bronco	1,056
A-10	1,056	T-38 Talon	1,056
Martin WB-57F Cabrera	1,056	Piper PA-31	5,808
Lockheed Martin F-16 Falcon	1,056	McDonnell Douglas F4 Phantom	1,056

As for the other airfields, GSE and APU assignment and emissions were also modeled using the EDMS defaults. The resulting inventory for Eielson is presented in Table 5.6-94.

Table 5.6-94
2008 EIL Emissions Inventory by Source Category (Metric Tons per Day)

Source	CO_2	CO	THC	VOC	TOG	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	155.062	0.669	0.092	0.106	0.106	0.653	0.064	0.006	0.006
APU	0.000	0.007	0.000	0.000	0.000	0.004	0.001	0.001	0.001
GSE	0.000	0.112	0.000	0.005	0.005	0.027	0.001	0.001	0.001
Totals	**155.062**	**0.685**	**0.092**	**0.110**	**0.111**	**0.713**	**0.065**	**0.009**	**0.009**

Combined Airfield Emissions Inventory - Taken in the aggregate, the three airfields included in the current analysis contribute only modestly to the overall emissions of the region. The vast majority of emissions associated with aircraft take off, landing and related ground support equipment occur near ground level which may result in increased exposure. Table 5.6-95 presents the combined emissions of the three analyzed airfields stratified by vertical layer.

The emission units in Table 5.6-95 differ from those in the earlier airfield-specific tables. EMDS output units of metric tons were used in those tables. They have been converted to tons in Table 5.6-95 for consistent comparison with other sectors of the emissions inventory. EDMS 5.1.3 does not estimate ammonia (NH_3) emissions for aircraft; thus as highlighted in gray in Table 5.6-95, they were assumed to be zero.

Table 5.6-95 2008 Combined Emissions Inventory of Aircraft Operations (Tons/Day)							
Layer	VOC	CO	NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$
1	0.0245	0.5222	0.1451	0.0045	0	0.0078	0.0076
2	0.3439	1.9753	0.8279	0.0983	0	0.0093	0.0093
3	0.0004	0.0082	0.0019	0.0002	0	0.0000	0.0000
4	0.0003	0.0049	0.0011	0.0001	0	0.0000	0.0000
5	0.0006	0.0111	0.0026	0.0003	0	0.0000	0.0000
6	0.0012	0.0240	0.0055	0.0007	0	0.0001	0.0001
7	0.0011	0.0215	0.0050	0.0006	0	0.0000	0.0000
8	0.0024	0.0462	0.0106	0.0013	0	0.0001	0.0001
9	0.0034	0.0670	0.0154	0.0019	0	0.0001	0.0001
10	0.0052	0.1016	0.0234	0.0028	0	0.0002	0.0002
11	0.0070	0.1374	0.0317	0.0038	0	0.0003	0.0003
12	0.0058	0.1656	0.0334	0.0036	0	0.0003	0.0003
13	0.0036	0.1570	0.0336	0.0032	0	0.0003	0.0003
14	0.0035	0.1559	0.0318	0.0030	0	0.0003	0.0003
15	0.0031	0.1300	0.0664	0.0047	0	0.0005	0.0005
16	0.0030	0.1552	0.0996	0.0063	0	0.0007	0.0007
17	0.0011	0.0830	0.0330	0.0022	0	0.0003	0.0003
18	0.0013	0.0990	0.0273	0.0019	0	0.0002	0.0002
19	0.0009	0.0608	0.0341	0.0022	0	0.0002	0.0002
20	0.0005	0.0137	0.0203	0.0012	0	0.0001	0.0001
21	0.0007	0.0096	0.0130	0.0013	0	0.0000	0.0000
Total	**0.4136**	**3.9490**	**1.4627**	**0.1441**	**0**	**0.0208**	**0.0206**

Spatial Allocation – In addition to the vertical layer allocations represented in Table 5.6-95, simple horizontal allocations of aircraft emissions were developed within a GIS system based on a map overlay of each of the three airfields and the modeling domains grid cells. Ground-based and elevated (climb out and approach) emissions were distributed into the 3-5 specific grid cells that encompassed the runway and taxiway/terminal apron areas of each airfield. (Refined allocations of climb out and approach emissions by horizontal and vertical cell reflecting typical in-air flight trajectories at each airfield were not developed given the magnitude of airfield emissions relative to the entire emissions inventory and significance of ground-based sources under the limited vertical mixing characterizing winter $PM_{2.5}$ episodes in Fairbanks.)

Summary of Non-Road Emissions

Table 5.6-96 provides a summary of annual emissions totaled across the modeling domain for each of the source "groups" within the non-road sector and by calendar year. Primary (i.e., direct) $PM_{2.5}$ emissions are highlighted in the rightmost column. To put these values in context, non-road sector $PM_{2.5}$ emissions represent less than 4% of the total emissions inventory.

Table 5.6-96
Non-Road Annual Emissions (tons/year) by Source Group and Calendar Year

Calendar Year	Non-Road Source Group	VOC	CO	NO_X	SO_X	NH_3	PM_{10}	$PM_{2.5}$
2008	NONROAD model sources	2,570	8,278	415	3	3	85	80
	Locomotives	24	71	454	8	0	14	13
	Aircraft (and GSE & APUs)	151	1,441	534	53	0	8	8
	Total Non-Road	**2,746**	**9,791**	**1,403**	**64**	**3**	**107**	**101**
2015	NONROAD model sources	1,859	6,723	306	1	4	64	60
	Locomotives	15	71	347	0	0	9	9
	Aircraft (and GSE & APUs)	151	1,441	534	53	0	8	8
	Total Non-Road	**2,026**	**8,236**	**1,186**	**54**	**4**	**81**	**77**
2019	NONROAD model sources	1,493	6,085	253	1	4	51	48
	Locomotives	11	71	278	0	0	7	7
	Aircraft (and GSE & APUs)	151	1,441	534	53	0	8	8
	Total Non-Road	**1,655**	**7,597**	**1,065**	**54**	**4**	**66**	**62**

Forecasted Control Measure Benefits

The preceding sub-sections of this appendix focused on describing the data sources, assumptions, methodologies and calculation workflows used to generate episodic emissions for the 2008 Baseline and 2015 and 2019 Projected Baseline inventories. This sub-section provides a detailed discussion of the approach used to calculate emission benefits from control measures analyzed in the SIP and used in the forecasted 2015 and 2019 Control inventories.

Measures Included in Control Inventories

Quantitative emission benefits were developed and applied in the Control inventories only for programs and measures for which existing data or reasonably developed projections were available. Although there are number of measures embodied in the SIP and associated State regulations, only those for which explicit data were available were directly accounted for in the Control inventories. These measures all target the space heating emission sector and consisted of the following:

- ARA Hydronic Heating Retrofit Program;
- FNSB Wood Stove Change Out Program;
- State Standards for New Home Heating Devices;
- State-Coordinated Wintertime Dry Wood Use Program; and
- Expansion of Natural Gas Availability.

Table 5.6-97 below lists the calendar year(s) for which each measure applies, as well as the Control inventory year(s) for which measure benefits were calculated. Implementation of the two State programs (Wood Device Standards in New Homes and Wintertime Dry Wood Use) is expected in mid-2015, thus the first full year for which their benefits apply would be 2016. Thus like Natural Gas Expansion, no benefits were modeled for these two State programs in the 2015 Control inventory. (But their accumulated benefits were modeled in the 2019 Control inventory.)

Table 5.6-97
Summary of Modeled Control Measures and Applicable Years

Modeled Control Measure	Year(s) for Which Measure Applies	Control Inventory Year(s)
ARA Hydronic Heater Retrofit Program	2012	2015, 2019
FNSB Wood Stove Change Out Program	2011 and later	2015, 2019
State Standards for New Home Heating Devices	2016[a] and later	2019
State-Coordinated Wintertime Dry Wood Use Program	2016[a] and later	2019
Expansion of Natural Gas Availability	2016[b] and later	2019

[a] Assuming these State programs are implemented in mid-2015, 2016 represent the first fully year for which their benefits would apply.

[b] Current Alaska Industry Development and Export Authority estimate, based on initial Interior Gas Utility construction phase slated for 2015 Q4.

Hydronic Heater Retrofit Program (ARA OHH Retrofits) – The Alaska Resource Agency (ARA) secured funding to identify and retrofit 40 outdoor hydronic heaters[100] (OHHs) with ClearStak or similar pollution control devices (PCDs). The retrofits were performed in late 2011 and 2012. The effects of these retrofits were not captured in the early 2011 Fairbanks Home Heating survey that was used to estimate the mix and number of devices in the SIP inventory and thus were treated as a control program with "fixed" benefits from those one-time retrofits.

FNSB Wood Stove Change Out Program (FNSB WSCO Program) – Beginning in June 2010, the Fairbanks Borough has operated a program within the non-attainment area designed to provide incentives for the replacement of older, higher-polluting residential wood-burning devices with new cleaner devices, or removal of the old devices. Table 5.6-98 presents a historical summary of how the WSCO program was originally designed and how it has been modified over time since it began.

As summarized in Table 5.6-98, the design of the WSCO program has evolved over time, but these changes have generally consisted of both increasing the financial incentives as well as expanding the types of solid fuel burning appliances (SFBAs) or devices that are eligible to participate in the program.

In estimating accumulated emission benefits from continuation of the WSCO beyond 2014, it was assumed that the current program design (circa March 2014 as listed in Table 5.6-98) would continue going forward. However, as explained in the following sub-section, the number of change outs in each future year was forecasted to decline over time reflecting an assumption that as the population of uncertified devices (and dirtier certified devices) declines, owners of those remaining devices are less likely to participate in the program than those who already have.

[100] Also called outdoor wood boilers (OWBs).

Table 5.6-98
Fairbanks Borough Wood Stove Change Out Program Historical Summary

Program	Old Appliance Type	New Appliance Type Allowed	Payout
JUNE 2010 – Original program. Limited to $PM_{2.5}$ non-attainment area. Participants in the removal program signed deed restriction in which they agree they would not install another solid fuel burning appliance for 10 years.			
Removal	OHH (Outdoor Hydronic Heater)	No solid fuel burning appliances	$7,500 cash
Removal	IHH (Indoor Hydronic Heater)	No solid fuel burning appliances	$4,000 cash
Removal	Other SFBA	No solid fuel burning appliances	$3,000 cash
Replacement	HH (outdoor or indoor) – non EPA Phase II	EPA Phase II, EPA cert SFBA or any pellet	Up to $2,500
Replacement	Other SFBA – non EPA cert	EPA cert SFBA or any pellet	Up to $2,500
Repair	Catalytic Converter	n/a	Up to $750
Repair	Other Emissions Reducing Component	n/a	Up to $750
Repair	Chimney Repair	n/a	Up to $750
Repair	Retrofit Device	n/a	Up to $1,000
JANUARY 2013 – In October 2012, Citizens' Initiative Prop 3 passed (The borough shall not, in any way, regulate, prohibit, curtail, nor issue fines or fees associated with sale, distribution, or operation of heating appliances or any combustible fuel.) Program suspended Dec. 2012 while it was modified. Opened to all Borough properties. Devices ≤ 2.5 grams/hr eligible for higher payout. Replacement devices must be EPA certified.			
Replacement	HH (outdoor or indoor)	EPA cert SFBA or pellet	Up to $2,500
Replacement	Other SFBA – non EPA cert	EPA cert SFBA or pellet	75% of cost up to $2,500/$3,000**
Removal	Remove HH w/out replacement		$2,000
Repair	Catalytic Converter	n/a	Up to $750
Repair	Other Emissions Reducing Component	n/a	Up to $750
Repair	Chimney Repair	n/a	Up to $750
Repair	Retrofit Device		Up to $1,000
ENHANCED PROGRAM (May – Sept 2013) – Completely different program (operated in conjunction with the regular program), limited to 3 specific areas in the non-attainment area. Also, allowed for replacing EPA-certified SFBAs with emission rate ≤ 2.0 grams/hr (overall emissions reduction must be at least 50%).			
Replacement	OHH	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $10,000
Replacement	Other SFBA	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $4,000
Replacement	Fireplace	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $4,000
MARCH 2014 (Current Program) – Changed to limit to properties in non-attainment area, and includes $300 fuel voucher for pellets or compressed logs. Now allows for replacing EPA-certified SFBAs w/emissions of 2.5 grams/hr and greater (and requiring an emission reduction of at least 50%), and fireplaces.			
Replacement	OHH	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $10,000
Replacement	Other SFBA	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $4,000
Replacement	Fireplace	EPA cert SFBA, any pellet, non-solid fuel burning appliances	Up to $4,000
Removal	Remove HH w/out replacement	n/a	$2,000
Removal	Remove SFBA w/o replacement	n/a	$1,000
Repair	Catalytic Converter	n/a	Up to $750
Repair	Other Emissions Reducing Component	n/a	Up to $750

Source: Fairbanks North Star Borough.
SFBA – Solid Fuel Burning Appliance.

State Space Heating Device Standards in New Homes – This DEC-headed program would require that space heating devices installed in new residential homes in the Fairbanks non-attainment area are EPA-certified devices meeting a 2.5 gram/hour $PM_{2.5}$ certification standard.

State-Coordinated Wintertime Dry Wood Use Program – A second DEC-led program would consist of a coordinated program designed to promote and potentially incentivize greater use of "dry" wood (defined as wood with a moisture content [MC] that does not exceed 20% on a dry basis). The projected wood moisture content in 2019 in the absence of such as program is 36.4%, averaged across the two wood source groups: (1) Buy (those who purchase wood commercially) and (2) Cut Own (those who cut, stack, and store their own wood).

Expansion of Natural Gas Availability in Fairbanks – A portion of the non-attainment area includes a limited delivery infrastructure for residential and commercial natural gas use from the existing Fairbanks Natural Gas (FNG) private utility. Plans are being coordinated and funding made available through several state agencies, led by the Alaska Industrial Development and Export Authority (AIDEA), to provide a sufficiently expanded infrastructure and delivery via expansion of FNG's infrastructure within its service area and additional gas delivery from a new public entity, the Interior Gas Utility (IGU), across an expanded area roughly encompassing the remainder of the non-attainment area. AIDEA is stewarding this expanded service with a goal of natural gas being priced at the retail, point of sale level of roughly half the existing cost of heating oil, or about $15-$17 per mcf (thousand cubic feet).

Control Measure Calculations

Detailed discussions of the emission benefit calculations for each modeled control measure are presented in this sub-section. Although the methodologies and assumptions used to estimate emission benefits in 2015 and 2019 (within the respective Control inventories) are described separately for each measure, the calculations and supporting data are contained within a single electronic spreadsheet, **ControlCalcs_FbksSIP_Final.xlsx**, contained in the electronic "SIP Analysis Files" archive submitted under separate cover from the SIP documentation. Elements of this spreadsheet are referenced in the following descriptions and for brevity, the spreadsheet itself is subsequently referred to as simply as the "ControlCalcs" spreadsheet.

Prior to calculating emission benefits for individual control measures, an analysis structure was set up in the *Calcs* sheet of the ControlCalcs spreadsheet to import 2008 baseline and projected baseline emissions within the non-attainment area by SCC code from externally-developed emission inventory (EI) summaries for the space heating sector. Workflow in the *Calcs* sheet was also set up to properly project heating device counts given effects of "natural" turnover of uncertified heating devices occurring outside of the WSCO program.

At the top of the Calcs sheet in the cell range A1:W83 a series of device count projections are shown by calendar year (beginning in 2011 based on data being utilized from the 2011 Home Heating survey). The upper table (Rows 1-42) shows projected device counts by device type based only on projected household growth (at roughly a 1.1% annual rate). The lower table (Rows 45-83) shows similar projections that also account for natural turnover of uncertified devices.

These device counts are calculated from extrapolations of the 2011 Home Heating survey and supporting data contained in the *HHSurvey11*, *Base11Counts2010* and *Base11Counts2020* sheets.

Below these project baseline device count tables, projected baseline space heating device emissions (tons/day or tpd), emission factors (lb/mmBTU) and usage (mmBTU/device-day) by SCC code are contained in the cell range A111:N230. Rows 77-112 contain projected 2011 baseline data; Rows 113-146 contain projected 2015 baseline data; Rows 153-186 contain projected 2017 data; and projected 2019 baseline data are in Rows 193-230. (The 2011 projections are used because of the year of the 2011 survey data on which a number of calculation elements are based. The 2017 data were generated in conjunction with the 2017 RFP inventory and linear progress assessment.) The projected baseline data in these ranges are imported from modeling inventory tabulations that are contained in the series of *DevSumOut* sheets for each future forecast year.

Beyond Column N in Rows 113-230 of the *Calcs* sheet, incremental emission benefits are then calculated for each of the five modeled control measures in the following order: 1) ARA Retrofits, 2) WSCO Program, 3) State Standards, 4) State Dry Wood Use; and 5) Natural Gas Expansion, and in left to right order in these section of the *Calcs* sheet. The order of calculated benefits is important to clarify because of the fact that some of these measures target the same source. Thus this serial workflow with an established order of applied control measures was used to ensure that overlapping benefits were not double-counted and that the benefits calculated reflect this order of measures considered in combination. The net emissions (and emission factors) after applying the effects of each measure by device/SCC become "inputs" to the emission calculations for the next serially-applied measure. The measure-specific calculations performed in this section of the *Calcs* sheet are discussed in further detail below for each control measure, along with locations of upstream data and assumptions in other specific sheets of the ControlCalcs spreadsheet.

<u>ARA OHH Retrofits</u> - The *ARAOHHCalcs* sheet of the ControlCalcs spreadsheet contains detailed calculations of the resulting emission benefits from retrofitting of 40 OHHs within the non-attainment area with ClearStak control devices. ARA estimated these retrofits provide an 80-90% reduction in particulate emissions based on testing conducted under a NESCAUM study. Based on visual observations/follow-up by Fairbanks Borough staff after retrofits were installed, a "real world" emission reduction of 30% per retrofit was assumed that accounted for imperfect compliance and use as shown in Cell V2.

The data provided by ARA included the street address, make and model of each retrofitted OHH and an ARA-supplied estimate of the amount of wood burned in each device (in cords per year). Emission factors (in lb $PM_{2.5}$/mmBTU) were then assigned to each device based on its make/model and additional descriptive "comment" data for the device provided by ARA. In short, devices were generally assigned emission factors of 0.57 lb/mmBTU for unqualified devices and factors that ranged from 0.18 to 0.32 lb/mmBTU for Phase 2 OHHs as identified using EPA's "Burnwise" certified OHH database[101]. (The 0.57 lb/mmBTU emission factor for unqualified OHHs was that developed for those devices in the baseline emission inventory.)

Participant addresses were checked against those available from the FNSB WSCO program. If a device was found to have also participated in the WSCO program after the ARA program, its ARA program emission benefits were zeroed to avoid double-counting. The effects of these discounts due to subsequent participation in the WSCO program are reflected in Columns Y-AA.

Total $PM_{2.5}$ emission reductions from retrofit of these devices under the ARA program (after removing benefits for those that subsequently participated in the WSCO program) were estimated to be 0.0046 tons/day for an average modeling episode day as shown in Cell AA46. This reduction represents 0.2% of projected baseline space heating emissions and roughly 0.1% of total emissions in the non-attainment area. (No benefits were assumed for gaseous pollutants.)

Because the ARA program was a "one-time" program, with funded retrofits performed in 2011-2012 (and post-dated the 2011 Home Heating survey upon which the baseline inventory was based), these control benefits were applied as a constant absolute reduction (in tons/day) in the 2015 and 2019 Control inventories. These calculations are contained in the *Calcs* sheet in the cell ranges of Q117:U142 for calendar year 2015 and Q197:U222 for calendar year 2019.

FNSB WSCO Program – Emission control benefits were calculated for the program based on transaction data collected by the Borough since its inception, through mid-August 2014. (Data for the partial 2014 calendar year were extrapolated to the end of 2014 based on the expected number of applications projected by the Borough to be completed and change outs validated by the end of the year.) The tabulated change outs (with Borough-based extrapolations through the end of 2014) are contained in cells A1:G28 of the *WSCOTabs* sheet in ControlCalcs.

For devices that were replaced, emission reductions were calculated by replacing the emission factor for each device type (fireplace, insert, wood stove, OHH/OWB, coal stove) with an emission factor (in lb/ton of fuel) equivalent to the emission rate cutpoints (in grams/hour) based on emission factor vs. emission rate correlations developed from certification data published by EPA[102] for over 1,000 wood-burning devices. For devices that were removed, it was assumed that the heating energy from the removed device would be replaced with equivalent energy from an oil furnace or boiler (and accounting for the heating efficiency differences between the two devices). No emission reductions were assumed for repaired devices given the uncertainty of the type of repair performed and its effect on emissions.

WSCO Program Benefits in 2015 - Emission benefits from the WSCO program for the 2015 Control inventory were based on the accumulation of change outs from the start of the program through the end of 2014 (extrapolating the partial 2014 data as described above). In attainment modeling, eligible control measure benefits are those that exist at the beginning of the modeling year. Thus in this case, WSCO program benefits accumulated through the end of 2014 (not 2015) were used to model attainment in calendar year 2015. A tabulation of the cumulative

[101] http://www.epa.gov/burnwise/owhhlist.html
[102] http://www.epa.gov/burnwise/appliances.html

year-to-year completed transactions in the WSCO is presented below in Table 5.6-99. Within each year, transactions are broken down by operation type (Replacement or Removal) and device type. As noted in the table title, these counts exclude repair transactions, unknown devices (types not known or recorded by the Borough) and indoor hydronic heater (IHH) transactions (since the small number of IHHs was not reflected in the baseline inventory).

Table 5.6-99
Fairbanks Borough Wood Stove Change Out Program Cumulative Transactions (Excluding IHHs, Unknown Devices and Repair Transactions)

Program Operation	Device Type	(end 2010) 2011	(end 2011) 2012	(end 2012) 2013	(end 2013) 2014	(end 2014) 2015
Replacement	Fireplace	0	0	0	0	74
Replacement	Stove/Insert	103	246	698	899	1,257
Replacement	OHH	1	3	5	22	43
Replacement	Coal Stove	0	0	1	3	10
Removal	Stove/Insert	10	44	184	190	194
Removal	OHH	8	32	68	70	74
Removal	Coal Stove	0	0	4	5	5
Replacements, Total		104	249	704	924	1,384
Removals, Total		18	76	256	265	273
Change-Outs, Total		**122**	**325**	**960**	**1,189**	**1,657**

These cumulative replacement/removal counts from the WSCO program were copied to the *WSCOTabsFnl* sheet. The *WSCOTabsFnl* sheet also contains calculations of average device emissions upon replacement by device type based on lookups of certification levels for replaced devices by device make and model from EPA's Burnwise certified device database coupled with lists of those specific device makes/models commonly sold in Fairbanks developed by ADEC from surveys of local heating device retailers. (The list of devices commonly sold locally contained in a separate spreadsheet file.)

The distributions of emission rates and emission factors for these locally-sold devices were used to determine the average emission rate/factor for devices that met a specific certification level (e.g., 2.5 grams/hour or g/hr). For example, from this local device emission rate distribution analysis, it was found that the average emission rates of woodstoves/inserts meeting standards of 2.5 g/hr and 2.0 g/hr were 1.9 g/hr and 1.4 g/hr, respectively as listed in cells F7 and F6 of the *Lookups* sheet.

Calculations are then performed in cells N1:Y17 of the *WSCOTabsFnl* sheet to account for the fact that beginning in 2014, woodstove, insert and fireplace replacements under the WSCO must meet 2.5 g/hr standard (which translates to an average emission rate of 1.9 g/hr as shown there based on average locally-sold device emissions meeting a 2.5 g/hr cutpoint.) These calculations are performed by calendar year to account for the changing average replacement emission rate over time, given the tighter replacement cutpoint established in 2014.

Within the cell range W115:BF144 of the *Calcs* sheet, cumulative WSCO device replacements/removal counts by device type from the *WSCOTabsFnl* sheet (and Table 5.6-99) are used to calculate emission benefits from these replacements/removals as of the end of 2014 (i.e., inventory year 2015). These cumulative counts are contains in Columns Y and Z of the Calcs sheet.

As explained earlier, separate calculations of emissions before and after device replacement or device removal are performed. "Before" emission factors are based on those from the projected baseline inventory except for OWB's, to reflect nominally lower emission factors that resulted from the ARA OHH Retrofit program. "After" emission factors for replaced devices are based on those developed by calendar year in the *WSCOTabsFnl* sheet. "After" emission factors for removed devices were calculated by assuming that the heating energy (in BTUs) from removed devices would be made up for by additional central oil furnace use. How much additional oil furnace use would occur was calculated on a net heating energy basis, which account for differences in relative efficiency between the various wood-burning devices and oil furnaces (which have higher heating efficiency than wood-burning devices). These before and after device replacement/removal calculations are contained in Columns AA through AA of the *Calcs* sheet.

The net effect of decreased emissions from removed/replaced devices and increased emissions from replacement devices and shifts to oil use due to wood device removal are summarized in Columns AT through BF. Calculations of "After WSCO Program" device counts, emissions for both $PM_{2.5}$ and SO_2[103], emission factors and device usage rates are contained there. In addition to computing emission reductions resulting from the WSCO Program, it was also necessary to adjust emission factors and usage rates for affected devices to ensure benefits from additional measures serially applied after the WSCO program were not double-counting combined measure effects as discussed earlier.

$PM_{2.5}$ emission reductions from the WSCO program in 2015 were estimated to be 0.394 tons/day across all heating devices as calculated in cell BA144 of the *Calcs* sheet. SO_2 emissions nominally increase by 0.015 tons/day, reflect greater use of oil heating devices assumed upon removal of existing wood devices under the program. In 2015, the program provides a 13.7% reduction in space heating $PM_{2.5}$ emissions in the non-attainment area relative to the projected baseline after accounting for the ARA program. Reductions for gaseous pollutants (relative to projected baseline space heating emissions) were estimated as 0.8% for SO_2, 1.4% for NOx, 19.3% for VOC and 10.3% for NH_3.

WSCO Program Benefits in 2019 - Emission benefits from continuation of the Borough's WSCO through 2019 were estimated by projecting additional annual change outs (either replacement of

[103] Though not calculated explicitly in the Calcs sheet, WSCO Program emission benefits for the other gaseous pollutants (NOx, VOC, NH_3) were scaled based on device-specific emission factors relative to $PM_{2.5}$. SO_2 emissions (and reductions) were directly computed in the Calcs sheet to explicitly account for the effect of removing wood devices (and heating energy) and replacing them with equivalent oil device emissions and heating BTUs, which have higher SO_2 emission factors (on a lb/BTU basis).

uncertified or higher-emitting certified devices with cleaner devices meeting a 2.5 gram/hour $PM_{2.5}$ standard, or removal of devices with their displaced heating energy replaced by heating from oil-fired units). Rather than simply assuming that annual WSCO program device replacements/removals would occur at their actual 2014 rate (or the average over the program's four-year history), a decreasing exponential curve was applied to account for the fact that as fewer and fewer uncertified devices exist over time, it will be harder to maintain existing annual participation levels or "throughput" in the program. This is depicted in Figure 5.6-38, which presents incremental annual change outs over time and shows the 2014 throughput as a constant horizontal blue line going forward and the assumed declining year-to-year trend shown below it in green. Calendar years shown reflect the start of the year, i.e., calendar year 2015 refers to change outs through the end of 2014.

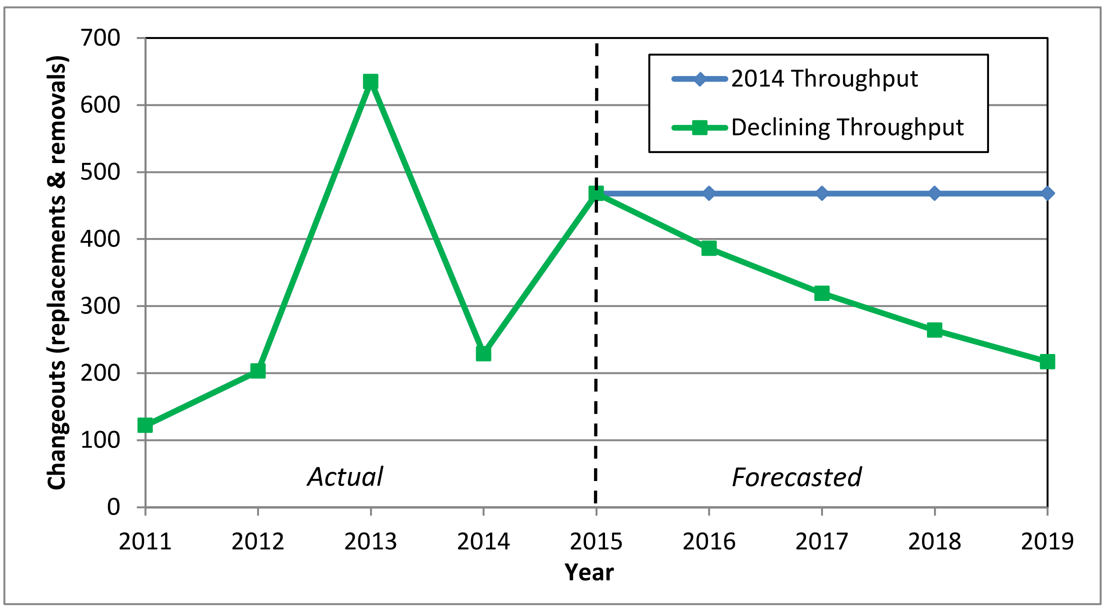

Figure 5.6-38. Incremental Annual Change Outs, Actual Through 2014 and Forecasted

To ensure that this declining throughput forecast properly accounted for the finite population of uncertified devices projected in the Borough in 2019 in the absence of the WSCO program, its rate of decline was set such that the forecasted number of uncertified wood stove and insert change outs in 2019 would approximately reach the "cap" of projected available population of those uncertified devices in that year (after accounting for natural turnover occurring outside the program). This is shown in Figure 5.6-39, which displays cumulative change outs of uncertified stoves and inserts over time and is seen where the green declining throughput forecast meets the projected uncertified stove/insert cap in 2019 (shown in red).

These population-capped declining throughput calculations are contained in cells A47:AD67 in the *WSCOTabs* sheet.

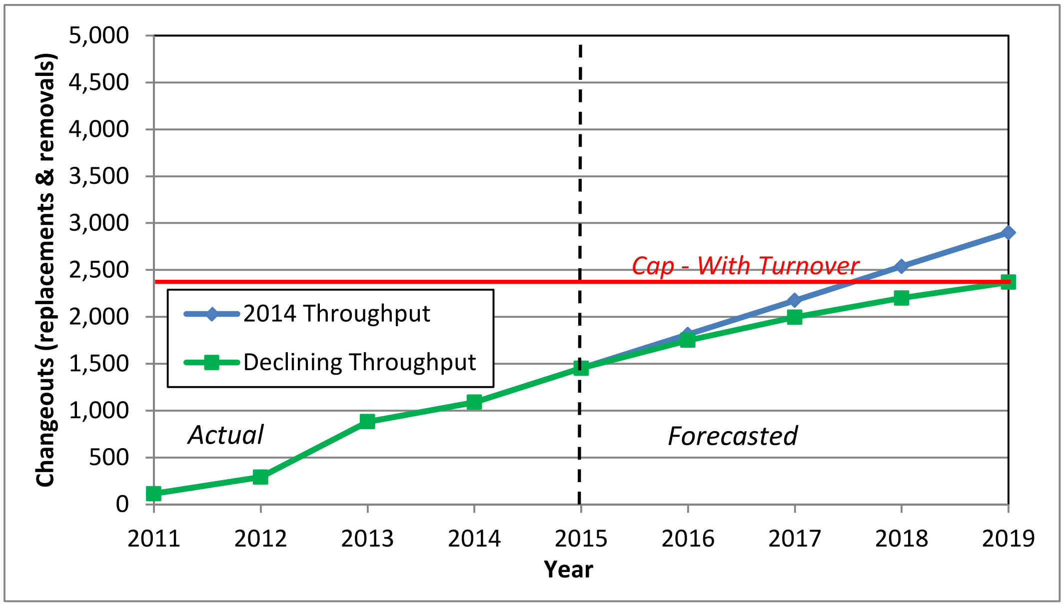

Figure 5.6-39. Cumulative Annual Change Outs, Actual Through 2014 and Forecasted, Uncertified Wood Stoves and Inserts

Figure 5.6-40 shows a similar plot of actual and forecasted cumulative annual WSCO program change outs for all uncertified devices. (All uncertified devices were represented as the sum of uncertified stoves/inserts, unqualified outdoor hydronic heaters, fireplaces, and coal heaters.) When all uncertified devices are plotted, there is still a margin between the projected number of cumulative change outs and the cap for all uncertified devices targeted under the current design of the WSCO program.

Again, calendar years shown refer to conditions as of the start of each year—i.e., calendar year 2019 refers to cumulative change outs through the end of 2018.

Similar computations for calendar year 2019 are performed in Rows 195-230 of the *Calcs* sheet to those described earlier for WSCO program benefits in 2015 (in Rows 115-146). In this case the number of devices replacements/removal under the program represent cumulative change outs in 2019 (end of 2018) based on projected continuation of the program, albeit with declining annual throughput over time.

As calculated in cells BA224 and BB224 of the *Calcs* sheet, the WSCO program is forecasted to produce a 0.748 ton/day reduction in $PM_{2.5}$ emissions and a 0.010 ton/day increase in SO_2 emissions in the non-attainment area. This corresponds to a relative[104] cumulative $PM_{2.5}$ reduction in space heating emissions from the WSCO program of 25.4% in 2019 (incremental to the ARA OHH retrofits).

[104] The relative reductions shown in the *Calcs* sheet are relative to the projected baseline and do not match those cited in this section, which are relative (or incremental) to the projected baseline after adjusting for effects of other serially-applied measures. The relative benefits cited are contained in the *Summary* sheet of the ControlCalcs spreadsheet.

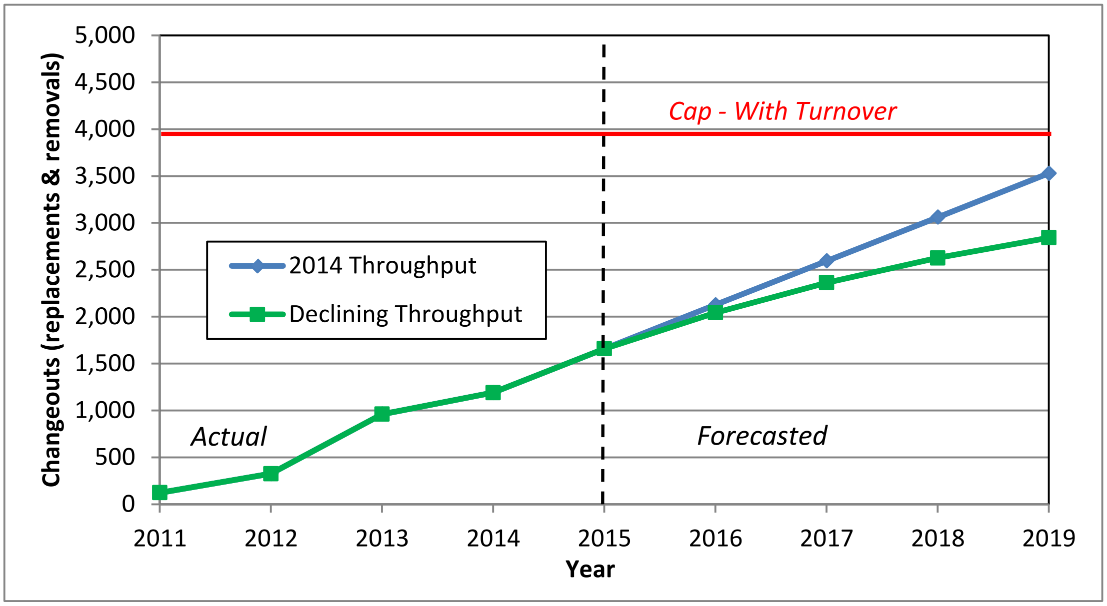

Figure 5.6-40. Cumulative Annual Change Outs, Actual Through 2014 and Forecasted, All Uncertified Devices

State Space Heating Device Standards in New Homes - Emission control benefits of such a program were developed using projections from the Borough's Community Research Quarterly publications.[105] Residential new homes were projected from 358 units in 2012 (actual) to 661 units in 2019 (start of calendar year) based on the long-term 2000-2012 trend published in the Quarterly. Since implementation of this State program is not expected until mid-2015, emissions benefits were only modeled for the 2019 Control inventory.

Emission reductions of $PM_{2.5}$ (no reductions were assumed for gaseous pollutants) were then estimated for 2.5 g/hr devices relative to the typical mix of uncertified/certified heating devices projected in 2019 and accounting for the overlapping effects of natural turnover and the WSCO program. Cells BJ195:BZ224 of the *Calcs* sheet contain the emission benefits calculations for the State Heating Device Standards measure in 2019.

Projected new home cumulative sales in 2019 (since assumed implementation in mid-2015) of 2,433 in Cell BJ197 were multiplied by the ratio of projected baseline devices to total households in the non-attainment area to estimate the number of wood devices that would need to meet the 2.5 g/hr standard in cells BJ204:BJ223. This was done to account for the fact that not all homes have a wood-burning device. A total of 627 wood devices were estimated to require "replacement" (over business as usual) or use of 2.5 g/hr certified devices.

The table in cells A9:G28 of the *Lookups* sheet contains translations of $PM_{2.5}$ emission rates (g/hr) at specific cutpoint levels to emission factors (lb/mmBTU). These translations use device-

[105] http://co.fairbanks.ak.us/communityplanning/crc/

specific multipliers for catalytic and non-catalytic woodstoves/inserts and OWBs developed from comparisons and linear regressions of certified emission rates and emission factors reported in EPA's Burnwise device database. (These regression-based multipliers were calculated in an external spreadsheet, **SpaceHeat_EF&ER_2013_WoodReplace_Calcs.xlsx**.)

Columns BM through BR use these translations of emission rate standards to an emission factor (ln/mmBTU) basis and contain calculations of Before and After emissions where Before emission factors for each device are based on baseline emission factors for each device and After factors are equivalent to a 2.5 g/hr standard. (Recall that a 2.5 g/hr standard translates to an average emission rate of 1.9 g/hr for devices sold in Fairbanks that are currently certified to meet a 2.5 g/hr standard.) Columns BS through BZ then contain calculations of the number of devices of each type/technology, average daily energy and fuel use, $PM_{2.5}$ emissions and emission reductions after applying the effects of the State Standards measure.

As shown in Cell BX224 of the Calcs sheet, total $PM_{2.5}$ emission benefits from the State Standards were estimated to be 0.045 tons/day, and provide an additional 1.6% reduction in 2019 space heating emissions (over and above the ARA and WSCO programs).

<u>State-Coordinated Wintertime Dry Wood Use Program</u> - Because such a program has not yet been adopted and is currently being evaluated by DEC, a series of plausible assumptions based on existing survey data were used to develop estimates of potential emission reduction benefits. From the 2013 Wood Tag survey, 34.3% of wood-using survey respondents indicated a willingness to pay up to $50 more per cord for dry wood knowing that dry wood provides roughly 25% more heating energy than wet wood (as explained in the Tag survey question). As a result, it was assumed that a coordinated wintertime Dry Wood Use program would result in 34% more homeowners from both the Buy and Cut Own wood source groups burning dry (20% MC) wood. (The movement of both the Buy group and the Cut Own group to use greater use of dry wood comes about from additional State education efforts that span both groups. It was assumed that the same relative shift toward greater dry wood use would occur in both groups.) Under this assumption, the composite wood moisture content would drop to 30.8% and result in a heating energy reduction in wood use of roughly 4%.

Calculations that show this change in composite average wood moisture (from 36.4% to 30.8% MC) are contained in the *Moisture* sheet of the ControlCalcs spreadsheet. For the Buy group, the baseline (before Dry Wood Use program) moisture content is 64.2% as shown in Cell I63 and was calculated as the average moisture content of wood purchased and burned during both January-February and November modeling episodes (cells C51 and C52). The baseline moisture content for the Cut Own group is 26.6% as shown in Cell I64 and was derived from moisture measurements in wood burning households in the CCHRC Instrumented study that were largely thought to be "Cut Own" households. Cells I69 and I70 contain calculated moisture contents for the Buy and Cut Own groups after applying the assumed 34.3% shift toward dry wood use. The resulting moisture levels reflecting this shift to greater dry wood use under the program are 49.0% and 24.3% for the Buy and Cut Own groups, respectively. Based on their relative usage fractions of 26.2% and 73.8% (cells E69 and E70), the resulting composite moisture content of 30.8% is shown in Cell I75.

The *Moisture* sheet also contains a series of formulas and a lookup table from those formulas shown the change in wood heating energy as a function of moisture content based on energy content reflecting the local mix of birch, spruce and aspen wood. Using the results in this lookup table, cell I77 shows an energy (BTU) adjustment factor of 0.959 that translates to a 4.1% reduction in wood use and thus, a commensurate reduction in wood-burning $PM_{2.5}$ emissions.

Back in the Calcs sheet, this translates to a $PM_{2.5}$ emissions benefit of 0.083 tons/day (Cell CK224), which represents an incremental $PM_{2.5}$ space heating emission reduction (on top of the preceding local and state measures) of 2.8% in 2019.

Expansion of Natural Gas Availability in Fairbanks - Estimates of emission reductions from natural gas expansion in 2019 (end of 2018) were developed based on forecasted residential and commercial penetration levels across the non-attainment area from a recent January 2014 AIDEA report prepared by Cardno-Entrix.[106] The Cardno report considered not just estimates of penetration (i.e. availability of gas at point of sale), but also addressed conversion/use for both the residential and commercial sectors and accounted for the costs of conversion for each sector. The combined residential household penetration and conversion to natural gas rate in 2019 estimated by Cardno was 36% at the end of 2018.

The Cardno report also included estimates of fuel use shifts (oil-to-gas, wood-to-gas) in converted households based on the targeted offering price for gas (about $2/gallon on a heating oil equivalent basis) and elasticity estimates that reflected a shift of roughly 77% of existing wood-burning homes to gas. This 77% estimate is very consistent with an 74% wood household shift to gas at $2/gallon oil equivalent developed from responses to a question in the 2013 Wood Tag survey. (These wood household shifts were based only on homes that had alternative heating sources beyond wood. In other words, they excluded homes solely heated using wood, which would be more difficult candidates for conversion to natural gas.)

The natural gas penetration rate projections by calendar year developed by Cardno and "shift to gas at price X" response results from the 2013 Tag survey are contained in the *NatGas* sheet in the ControlCalcs spreadsheet. The Tag survey data are in Rows 1-25 and the Cardno-based gas penetration projections are provided in Rows 87-103.

The wood-to-gas household shifts were combined with an additional element from the 2013 Tag survey that found roughly 38% of wood users would still likely burn wood on extremely cold days (defined as days below -30°F) to produce a "discounted" shift to gas use estimate use on those cold days of 26.5% (36% × [1-38%]).

Cells DH195:FI230 within the *Calcs* sheet contain the emission benefit calculations for natural gas expansion based on these assumptions. This section of the *Calcs* sheet contains two variants for natural gas expansion benefit calculations, one which evaluated natural gas benefits in conjunction with use of energy logs, the other without inclusion of energy log effects. As

[106] "IEP Natural Gas Conversion Analysis, Fairbanks LNG Distribution System Demand Analysis," prepared by Cardno Entrix for Alaska Industry Development and Export Authority, January 2014.

explained in Section 5.6 of the SIP, an energy log use program was evaluated by DEC but not included in the final SIP modeling due to current uncertainty regarding consumer demand for the logs, which just began being produced and sold in summer/fall of 2014. Thus, only the "Without Energy Logs" case is relevant.

Emission factors by device (lb/mmBTU) after adjusting for effects from other "upstream" control measures are contains in Columns DH and DI. Column DL identifies those devices for which heating energy-equivalent shifts to natural gas were assumed (all wood and oil device types). Column DM contains calculated "Natural Gas Efficiency Factors" which are device-specific multipliers that account for differences in net heating efficiency for each device relative to natural gas. (Oil devices were assumed to have the same 81% net heating efficiency as natural gas.) Columns DN through DQ contain calculations of "removed" devices, energy and emissions displaced by expanded natural gas use. Columns DR through DU contain calculations of devices (households in this case), energy and emissions added from expanded natural gas use. The energy removed and energy added totals across all devices in cells DO224 and DS224 are not equal because they reflect fuel or "raw" energy use; the lower total for added energy accounts for the fact that natural gas heaters have a higher net heating efficiency that the composite average of other wood and oil devices being displaced. The amounts of energy displaced by device (Column DO) are calculated based on the incremental participation rate in expanded natural gas use, which in 2019 was estimated as 36.0% on "warm" days (above -30°F) and 26.5% on cold days (below -30°F) as explained earlier. The added energy from expanded natural gas use in Column DS is calculated using the Natural Gas Efficiency Factors. Once these displaced and added energy increments were calculated, the resulting emission reductions (for wood and oil devices) and increases for residential natural gas were easily calculated from the device specific emission factors in Columns DH and DI. Columns DV and DU then contain net emission reductions by device for $PM_{2.5}$ and SO_2, respectively.

Columns DN through DY perform these calculations for days above the -30°F temperature threshold (and without energy logs). A similar set of calculations for days below the temperature threshold are contained in Columns DZ through EK.

Using these data sources and assumptions, incremental $PM_{2.5}$ emission reductions from natural gas expansion across the non-attainment area in 2019 were found to be 16.4% on cold (<-30°F) days and 18.4% on warmer (≥-30°F) days relative to the 2019 projected baseline. These incremental reductions are those above that from preceding state and local measures after accounting for overlapping effects.

Summary of Calculated Emission Benefits

Table 5.6-100 and Table 5.6-101 summarize the calculated emission benefits of each control measure that were calculated as described above and applied within the 2015 and 2019 Control inventories, respectively. In each table, space heating emissions of direct $PM_{2.5}$ and SO_2 (in tons/day, tpd) over the non-attainment area are shown as a function of the projected baseline and the applicable control measures (and their penetration) for the given calendar year. Reductions for natural gas expansion are shown on both an average "Cold" (below -30°F) and "Warm" (above -30°F) episode day basis.

Table 5.6-100 2015 Average Episodic Non-Attainment Area Space Heating Emissions (tons/day) and Relative Emission Reductions (%) by Control Measure							
Quantity	Projected Baseline	ARA OHH Retrofits	WSCO Program	State Standards	State Dry Wood Use	Expand Natural Gas	
						Cold	Warm
Space Heat Emissions, $PM_{2.5}$ (tpd)	2.834	2.830	2.440	n/a	n/a	n/a	n/a
Space Heat Emissions, SO_2 (tpd)	4.303	4.303	4.318	n/a	n/a	n/a	n/a
Relative Cumul. $PM_{2.5}$ Reductions (%)[a]	n/a	0.2%	13.9%	n/a	n/a	n/a	n/a
Relative Cumul. SO_2 Reductions (%)[a]	n/a	0.0%	-0.3%	n/a	n/a	n/a	n/a
Relative Increm. $PM_{2.5}$ Reductions (%)[b]	n/a	0.2%	13.7%	n/a	n/a	n/a	n/a
Relative Increm. SO_2 Reductions (%)[b]	n/a	0.0%	-0.3%	n/a	n/a	n/a	n/a

[a] Cumulative reductions relative to the 2015 projected baseline.
[b] Incremental (non-overlapping) reductions relative to the preceding measure.
n/a – Not applicable.

Table 5.6-101 2019 Average Episodic Non-Attainment Area Space Heating Emissions (tons/day) and Relative Emission Reductions (%) by Control Measure							
Quantity	Projected Baseline	ARA OHH Retrofits	WSCO Program	State Standards	State Dry Wood Use	Expand Natural Gas	
						Cold	Warm
Space Heat Emissions, $PM_{2.5}$ (tpd)	2.937	2.933	2.184	2.140	2.056	1.740	1.548
Space Heat Emissions, SO_2 (tpd)	4.537	4.537	4.547	4.547	4.544	4.009	3.683
Relative Cumul. $PM_{2.5}$ Reductions (%)[a]	n/a	0.2%	25.6%	27.2%	30.0%	40.8%	47.3%
Relative Cumul. SO_2 Reductions (%)[a]	n/a	0.0%	-0.2%	-0.2%	-0.1%	11.6%	18.8%
Relative Increm. $PM_{2.5}$ Reductions (%)[b]	n/a	0.2%	25.4%	1.6%	2.8%	10.8%	17.3%
Relative Increm. SO_2 Reductions (%)[b]	n/a	0.0%	-0.2%	0.0%	0.1%	11.7%	18.9%

[a] Cumulative reductions relative to the 2019 projected baseline.
[b] Incremental (non-overlapping) reductions relative to the preceding measure.
n/a – Not applicable.

Relative benefits from each applied measure are also presented in two ways: 1) cumulatively relative to the applicable projected baseline; and 2) incrementally relative to emissions after applying the effects of each preceding measure in the left-to-right order listed (and accounting for overlapping effects as described earlier). Relative reductions shown in red (with negative signs) in each table represent emission increases.

The gray-shaded area of Table 5.6-100 reflects the fact that measures in those columns were assumed to not yet apply in the 2015 Control inventory. Therefore no benefits for these measures were modeled in 2015.

The *SMOKERedns* sheet in the ControlCalcs spreadsheet contains relative benefits by SCC code and pollutant that were applied to the SMOKE-ready projected baseline inventory files and used to generate model-ready Control inventories. (Benefits for gaseous pollutants other than SO_2 generally scaled with $PM_{2.5}$ reductions except where noted earlier.)

EMISSION INVENTORY DATA FILES

This final sub-section summarizes the key data files used to perform calculations and develop the SIP emission inventories. They include calculation and summary spreadsheets, inventory modeling files (e.g., MOVES and NONROAD files) and files developed for input to the SMOKE inventory pre-processing model. These files are described separately by source sector and also include summaries of other supporting files used in the inventory workflow.

STATIONARY POINT SOURCE FILES

Key point source data files consist of the following:

- **Fac*.xlsx –** Spreadsheets containing episodic activity data, emission unit data and stack data for each stationary point source facility. They include fuel and process descriptions as well as calculations of emissions by day and hour for 2008 calendar days encompassing the two historical modeling episodes.

- **Actual_vs_PTE.xlsx** – Spreadsheet compilation of average Episode 1, Episode 2, 2008 Actual and PTE average daily emissions from each facility (used to generate facility emission comparison plots presented earlier in this appendix).

STATIONARY NON-POINT (AREA) SOURCE FILES

Key area source data files include the following:

- **G3C_SpHtArea_*yyyy*F*Case*_11Tag_Episodes.xlsm –** A series of macro-driven spreadsheets used to calculate episodic day and hour specific space heating emissions by grid cell, device type/SCC code and pollutant. In the filenames ***yyyy*** represents the calendar year and ***Case*** indicated identifies whether the file represents baseline (B) or projected baseline (PB) emissions. These spreadsheets apply the Home Heating Energy Model along with other space heating emission calculation elements described in earlier sections of this appendix to generate episodic, gridded space heating emissions estimates that are outputted to external files by the spreadsheet macro and subsequently formatted for SMOKE and attainment modeling use.

- **G3C_ARNR_*yyyy*FPBase.xlsx –** A series of spreadsheet files used to compile and output modeling emissions for both other stationary area (AR) sources (i.e. excluding space heating sources) as well as non-road mobile sources (NR) by pollutant and SCC code, where ***yyyy*** represents the calendar year. These spreadsheets prepare CSV and fixed field-width data files for export of annual county-wide emissions and associated spatial and temporal surrogate data and profile files required by SMOKE.

ON-ROAD MOBILE SOURCE FILES

On-road mobile source data files include:

- **MOVES_Inputs_ModelRuns_2008Backcast _20130109.xlsx** - Spreadsheet used to calculate the vehicle activity and population inputs for MOVES2010a runs for all modeled calendar years.

- **MOVES2010a_Importer_*yyyy*.xls** – MOVES importer input data spreadsheet used for driving the MOVES2010a runs for the calendar year ***yyyy***. This file contains vehicle activity and characteristics required for a MOVES2010a simulation.

- **raterperdistance_smoke_2090_*yyyy*_ozonepmfbks_*ep#*.csv** – MOVES rate-per-distance lookup table used in SMOKE for generating photochemical model ready onroad mobile running exhaust emissions data. Files are generated separately by year ***yyyy*** and episode number ***#***.

- **raterpervehicle_smoke_2090_*yyyy*_ozonepmfbks_ep#.csv** – MOVES rate-per-vehicle lookup table used in SMOKE for generating photochemical model ready onroad mobile starting and idling exhaust emissions data. Files are generated separately by year ***yyyy*** and episode number ***#***.

- **raterperprofile_smoke_2090_*yyyy*_ozonepmfbks_ep#.csv** – MOVES rate-per-profile lookup table used in SMOKE for generating photochemical model ready onroad mobile evaporative emissions data. Files are generated separately by year ***yyyy*** and episode number ***#***.

- **VPOP_MONTHS_*yyyy*.csv** – Monthly vehicle population data used in SMOKE emissions calculations for rate-per-vehicle on-road mobile sources for each calendar year ***yyyy***.

- **VMT_MONTHS_*yyyy*.csv** – Monthly vehicle VMT data used in SMOKE emissions calculations for rate-per-distance on-road mobile sources for each calendar year ***yyyy***.

- **SPEED_MONTH.csv** –Winter average vehicle speed data used in SMOKE emissions calculations for rate-per-distance on-road mobile sources.

Non-Road Mobile Source Files

Key non-road mobile source data files consist of the following:

- **G3C_ARNR_*yyyy*FPBase.xlsx** – See description under "Stationary Non-Point Source Files."

- ***cty*_*yyyy*_Ann.xlsx** - Spreadsheets containing imported NONROAD emissions modeling outputs by inventory calendar year (***yyyy***) and county (***cty***) where county names are Denali, FNSB, SEFairbanks and Yukon and reflect the four counties containing area within the attainment modeling domain. These spreadsheets are used to reformat the NONROAD emission data into a structure for use within SMOKE and to perform spatial and temporal adjustments that could not be handled directly within NONROAD (e.g., snowmobile activity inside and outside the Fairbanks non-attainment area).

OTHER FILES

Other key data files include of the following:

- **HHBTU_Model_Adj.xlsx –** A spreadsheet containing the validated BTU estimates by household, day and hour from the CCHRC Instrumented study and calculations of the regression coefficients for the Home Heating Energy Model.

- **FNSB_2011_Survey_Tabulations_2010HHWts.xlsx –** Contains the raw and cleaned/validated results from the 2011 Home Heating survey and tabulations of those results that were exported for use in performing the episodic space heating emission inventory calculations.

- **SpaceHeat_EF&ER_2013_WoodReplace_Calcs.xlsx –** A spreadsheet containing compilations of certified heating device data by make and model from EPA's Burnwise database. These data include certified emission rate, minimum and maximum energy output, technology type and efficiency. They were used to develop correlated translations of emission rates (g/hr) to emission factors (lb/mmBTU).

- **ControlCalcs_FbksSIP_Final.xlsx –** The spreadsheet discussed in detail in the preceding section of this appendix in which the control measure benefits are calculated and exported for use in the 2015 and 2019 Control inventories.

In addition to the files specifically listed above, an electronic archive of modeling data files that are too numerous to list here was prepared for separate submittal/transmittal to EPA.

Attachment A

Fairbanks Home Heating & Wood Household Survey Scripts

Fairbanks 2011 Home Heating Survey

Final Script

Phone # _______________ Survey # __________
Interviewer Name ___________________
Date _______________

(Location of Home)

Good evening, I am calling from Hays Research Group; we are conducting a brief survey on behalf of the Alaska Department of Environmental Conservation (ADEC) and the Fairbanks North Star Borough (BURR-oh) regarding home space heating options. May I please speak to the person most knowledgeable about the heating devices in your home? (IF NOT AVAILABLE – When would be the best time to reach him/her? Set a callback and get a name.)

Q1-Q8) Please tell me which of the following devices provide space heat for your home?

Q1) A wood burning device?

1. Yes
2. No
3. DK/REF

Q2) A central Oil furnace?

1. Yes
2. No
3. DK/REF

Q3) Portable Fuel Oil/Kerosene heating device?

1. Yes
2. No
3. DK/REF

Q4) Toyo (TOY-oh), Monitor or other direct vent type heater?

1. Yes
2. No
3. DK/REF

Q5) Natural Gas Heat?

1. Yes
2. No
3. DK/REF

Q6) Coal Heat

1. Yes
2. No
3. DK/REF

Q7) Municipal Heat?
1. Yes
2. No
3. DK/REF

Q8) Other not listed? ___________________

QQ) And can you please tell me how many square feet are in your home, not including any garage space?

1. ________________sq. ft.
2. DK/REF

(At least one of the questions between Q1-Q7 must = 1 yes, otherwise terminate)

(Ask Q1a if Q1=1, otherwise skip to Q9)

Q1a) Is your wood burning device a fireplace, a fireplace with insert, a wood burning stove or outdoor wood boiler?

1-Fireplace
2-Fireplace with insert
3-Wood burning stove
4-Outdoor Wood Boiler (note could called hydronic heater by some)
5-DK/REF

Q9) (Q9 answers must total 100%) What percentage of your heating is done by each of the following devices during the winter months, from October to March?

a. Wood Burning Device	%
b. Central Oil furnace	%
c. Portable Fuel Oil/Kerosene	%
d. Direct Vent type	%
e. Natural Gas Heat	%
f. Coal Heat	%
g. Municipal Heat	%
h. Other	%

We'll now get into some usage details of each type of heating.

(Section 1: Wood burning stove/Fireplace insert)

(Ask Q10-Q12 if Q1a = 2) "Fireplace with insert" or 3) "Wood burning stove", otherwise skip to Q13)

Q10a) Was your wood burning stove or insert installed before or after 1988?

1) Before
2) After
3) DK/REF

Q11a) How old is your wood burning stove or insert? Allow multiple responses

1) Less than 1 year
2) 1-5
3) 5-10
4) 10-15
5) 15+ years
6) DK/REF

Q11b) Is your wood stove or insert catalytic or non –catalytic?

1) catalytic
2) non-catalytic
3) DK/REF

Q12) Does your stove or insert burn pellets or cord wood? Allow multiple responses

1)Pellets
2)Cord Wood
3) DK/REF

(Ask Q13-Q14 if Q12=2 “Cord wood”, otherwise skip to Q15)

Q13) What best describes your use of wood heat during the winter months, October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don’t know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q14) Where do you get the wood for your heating? Allow multiple responses
1. Buy wood
2. Cut your own
3. DK/REF

(Ask Q15-Q17a if Q14=2 “Cut your own”, otherwise skip to Q18)

Q15) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q16) How many months do you season your wood before burning it?

1._______Months
2. DK/REF=9999

Q17) Do you know what the moisture content of your wood is, and if so, what is it?

1._______Percent
2. DK/REF=9999

(Ask Q18-Q19 if Q12 =2 “Cord wood”, otherwise skip to Q20)

18) In cords, how much wood do you burn in your wood burning stove or insert annually?
(If the respondent asks, one cord of wood is four feet wide, four feet high, and eight feet long stacked)

1. Wood in cords ______
2. DK/REF=9999

Q19) In cords, how much do you burn from October to March?

1. Wood in cords ______
2. DK/REF=9999

(Ask Q20-Q21 if Q12=1 “pellets”, otherwise skip to Q22)

Q20) How many 40 lb bags of pellets do you burn in your wood burning stove or insert annually?

1. 40 lb bags of pellets ________
2. DK/refused=9999

Q21) How many bags do you burn from October to March?

1. 40 lb bags of pellets ________
2. DK/refused=9999

(Ask Q22 if q18 or q19= DK/REF, otherwise skip to Q23)

Q22) How much do you spend per year on wood?

1. $__________
2. DK/refused=9999

(Ask q23 if q20 or q21 = DK/REF, otherwise skip to Q24)

Q23) How much do you spend per year on pellets?

1. $__________
2. DK/refused=9999

Q23a) Is there a pellet source that you prefer?

1. Yes
2. No
3. DK/REF

(Ask Q23b if Q23a=”Yes”, otherwise skip to Q24)

Q23b) Why do you prefer that source?

Specify ___________

(Section 2: Wood burning Fireplace)

(Ask Q24-Q25 if Q1a = 1 “Fireplace”, otherwise skip to Q32)

Q24) From this list, what best describes your use of wood heat during the winter months, from October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q25) Where do you get the wood for your heating? (Allow multiple responses)

1. Buy wood
2. Cut your own
3. DK/REF

(Ask Q26-Q31 if Q25=2, otherwise skip to Q32)

Q26) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q27) How many months do you season your wood before burning it?

1. Months ______
2. DK/refused=9999

Q28) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent ______
2. DK/refused=9999

Q29) In cords, how much wood do you burn in your fireplace annually?

1. ________cords
2. DK/refused = 9999

Q30) How much do you burn from October to March?

1. ________cords
2. DK/REF=9999

Q31 How much do you spend per year on wood?

1. $__________
2. DK/REF=9999

(Section 3: Outdoor Wood Boiler)

(Ask Q32-Q33 if section if Q1a = 4 “outdoor wood boiler”, otherwise skip to Q34)

Q32) What best describes your use of wood heat during the winter months, from October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don’t know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q33) Where do you get the wood for your heating? (allow multiple responses)

1. Buy wood
2. Cut your own
3. Purchase Pellets
4. DK/REF

(Ask Q34-Q36 if Q33=2 “cut your own”, otherwise skip to Q37)

Q34) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q35) How many months do you season your wood before burning it?

1. Months ______
2. DK/REF=9999

Q36) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent ______
2. DK/REF=9999

Q37) How much wood do you burn in your outdoor wood boiler annually?

1. _________cords
2. _________ pellets
3. DK/REF=9999

Q38) How much do you burn from October to March?

1. _________cords
2. _________ pellets

3. REF=9999

(ask Q39 if Q33= 1 “Buy wood”, otherwise skip to Q40)

(ask Q38a if Q33= 3 “Purchase Pellets”, otherwise skip to Q40)

Q38a) Is there a pellet source that you prefer?

1. Yes
2. No
3. DK/REF

(Ask Q38b if Q38a=”Yes”, otherwise skip to Q40)

Q38b) Why do you prefer that source?

Specify ___________

Q39) How much do you spend per year on wood?

1. $__________
2. DK/REF=9999

Q40) What is the brand name of your outdoor wood boiler? (open ended)

(Section 4: Central Oil)

(ask Q41-Q44 of Q2=1 “yes”, otherwise skip to Q45)

Q41) How large is your fuel oil tank, in gallons?

1. _______Gallons
2. DK/REF=9999

Q42) In gallons, how much oil do you use annually?

1. _______Gallons
2. DK/REF=9999

Q43) How many gallons do you use during the winter months (October – March)?

1. _______Gallons
2. DK/REF=9999

Q44) How much do you spend per year on fuel oil?

1. $__________
2. 9999=No/DK/REF

(Section 5: Portable Fuel Oil/Kerosene Heating Device)

(Ask Q45-Q46 if Q3=1 “YES”, otherwise skip to Q47)

Q45) You mentioned using a Portable Fuel Oil or Kerosene Heating Device, does the device use Fuel Oil?

1. Yes
2. No
3. DK/REF

Q46) Does the device use Kerosene?

1. Yes
2. No
3. DK/REF

(If Q45 OR Q46 = 1 “yes”, read Q47-Q48, otherwise skip to Q49)

Q47) In gallons, how much oil/kerosene do you use annually?

1. ________gallons
2. DK/REF=9999

Q48) How many gallons do you use during the winter months (October – March)?

1. ________gallons
2. DK/REF=9999

Q49) How much do you spend per year on oil/kerosene? No/DK/REF=9999

1. $________
2. DK/REF=9999

(Section 5.1
For homes using Central Oil, and/or Portable Fuel Oil/Kerosene Heating Devices, and/or Other devices)

(Ask Q50 if Q2=1 “yes” or Q3=1 “yes” or Q7=1 “yes”, otherwise skip to Q51

Q50) From this list please tell me what best describes your use of fuel oil and kerosene burning devices during the winter months, from October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Section 6: Toyo, Monitor, or other Direct Vent Type of Heater if uses fuel oil and direct vent fuel consumption question

(Ask this section if Q4=1 "yes", otherwise skip to Q55)

If Q2=1 and Q4=1 skip Q 51 & Q52

Q51) In gallons, how much oil do you use annually?

1. _______Gallons
2. 9999=DK/refused

Q52) How many gallons do you use during the winter months (October – March)?

1. _______Gallons
2. 9999=DK/REF

Q53) How much do you spend per year on oil?

1. $________
2. 9999=DK/REF

Q54) What best describes your use of direct vent heating device during the winter months, from October to May?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Section 7: Natural Gas Heating Device

(if Q5=1 "yes", ask Q55-Q56, otherwise skip to Q57)

Q55) How much do you spend on natural gas annually?

1. $________
2. DK/REF=9999

Q56) How much do you spend during the winter months, from October to March?

1. $________
2. DK/REF=9999

Section X: Coal Heating Device

(if q6=1 “yes”, ask Q57-Q60, otherwise skip to Q61)

Q57) How much coal do you use annually?

1.__tons
2.__bags
3. DK/refused

Q58) How much did you pay for the coal?

1.___$/bag
2.___$/ton
3. DK/refused

Q59) How much coal do you use during the winter (October – March)?

1.__tons
2.__bags
3. DK/refused

Q60) Is your coal burned in an indoor stove or an outdoor boiler?

1. Indoor stove
2. Outdoor boiler
3. DK/refused

(Section F: Municipal Heat)

If Q7=1 “yes”, ask Q61-Q62, otherwise skip to Q63)

Q61) How much do you spend on municipal heat annually?

1. $________
DK/refused =9999

Q62) How much do you spend on municipal heat during the winter months, October to March?

1. $________
DK/REF=9999

Future Section (to be completed for every survey)

Q63) Do you anticipate acquiring a new or different type of heating device within the next 2 years?

1. Yes
2. No
3. DK/refused

(If Q63=1 "yes", ask Q64, otherwise skip to

Q64) What type of device do you plan to acquire? READ LIST

a. Wood Stove	d. Fuel Oil		h. Don't know (do not read)
b. Wood Pellet	e. Kerosene		i. Refused (do not read)
c. Outdoor Wood Boiler	f. Coal stove	g. Outdoor coal boiler	j Other (Specify)

(If Q64= a. 'Wood stove", ask Q64a, otherwise skip to Q65)

Q64a) Newer EPA certified stoves are more efficient and require less chimney cleaning than older stoves. These benefits ultimately offset the purchase price, particularly if you hire chimney sweepers. How quickly would a new stove need to pay for itself in order for you to buy one?

1. 1 year
2. 2 years
3. 3 years
4. 4 years
5. 5 years or more
6. None
7. Don't Know/Refused (do not read)

Q64b) Would you invest in a new more efficient stove if you were to receive a price incentive paid by either state or local government of $250? (like a rebate)

1. Yes
2. No >> ask 64c

if answer to 64 b is no then proceed to 64c:
Q64c) What if the price incentive was $500?

1. Yes
2. No >> ask 64d

if answer to 64 c is no then proceed to 64 d:

Q64d) And if the price incentive were $750, would you invest in a new stove?

1. Yes
2. No >> ask 64e

if answer to 64 d is no then proceed to 64 e:
Q64e) What if the incentive were $1,000?

1. Yes
2. No >> ask 64f

if answer to 64e) is no then proceed to 64f)

Q64f How much of an incentive would it take for you to invest in a new stove?

1. $1000 – 1200
2. $1201 – 1500
3. $1501 – 1750
4. $1751 – 2000
5. $2001 or more
6. DK/refused

(If Q1a=1 or Q12=2 ask Q65-Q68, otherwise skip to Q69)

Q65) Did you burn more wood this winter to minimize the cost of heating oil?

1. Yes
2. No
3. DK/REF

Q66) What fuel oil price would cause you to shift away from using wood for heating?
(If respondent is unclear of question ask: If fuel oil prices decline, at what price will you shift to using more fuel oil to heat and decrease the use of wood?)

Specify:____________

Q67) Natural gas is currently priced at $2.34/hundred cubic feed which is equivalent to $3.04 of #2 Heating Oil. How much lower would natural gas need to be priced to cause you to shift away from fuel oil? (If respondent is unclear of the question, ask what the equivalent fuel oil price per gallon that would cause them to shift away from fuel oil?)

Specify:____________

(ASK Q68 ONLY IF ZIP=99709, otherwise skip to Q69)

Q68) Can you please tell me whether you live inside of Chena Ridge (to the east of the ridge) or outside of Chena Ridge (to the west of the ridge).

1. Inside Chena Ridge
2. Outside Chena Ridge
3. DK/REF

(ASK Q69 ONLY IF ZIP=99712, otherwise skip to Q70)

Q69) Can you please tell me if you live inside of Farmers Loop Road or outside of Farmers Loop Road?

1. Inside Farmers Loop Road
2. Outside Farmers Loop Road
3. DK/REF

(ASK ALL)

Q70) Are you being impacted by wood smoke from your neighbors?

1. Yes
2. No
3. DK/REF

Q71) Does the Borough have a winter time air quality problem?

1. Yes
2. No
3. DK/REF

Q72) How do you keep abreast of current issues is it (read list, allow more than one answer)

1. TV
2. Radio
3. Newspaper
4. Internet
5. Other
6. DK/refused

Thank you, that is all the questions I have this evening. If you have questions or comments about this survey, I can give you the contact information for Hays Research Group. Again, thank you for your time.

2013 Wood-Burning Household Tag Survey

Intro / Screener

Hello, this is ___________ calling from Hays Research Group, an Alaskan research firm. We are conducting a survey today on behalf of the State and The Fairbanks Northstar Borough to gather information about specific models of heating devices to help us better understand the air quality issues in the area. Your number was selected at random, and all information collected will be kept confidential, your name address and phone number will not be included in any of the information given to the State or Borough. Can I speak to the person in the household who would be most knowledgeable about heating methods in your home?

Q1)Do you use any wood-burning heating devices in your house during winter?

(this could include wood stoves, fireplaces, hydronic heaters, outdoor wood boilers and pellet stoves)

1. Yes (continue)
2. No or Don't know / Refused (terminate "the survey today deals with wood heating devices, so you are ineligible to participate, thanks for your time")

Q2)What type of wood device(s) do you use? Read list (multiple answers OK)

1. Wood Stove
2. Pellet Stove
3. Insert
4. Fireplace
5. Hydronic heater (sometimes referred to as an outdoor wood boiler)
6. Other (specify) – removed 20913
7. (Don't know/Refused) - terminate

[IF Q2=1. WOOD, ASK Q3-Q9]

WOOD STOVE SECTION

Q3) I am going to ask you a few questions about your wood stove. Are you able to look at it to give me some specific information?

1. Yes
2. No (ask if there is a better time to call back)

Q4)What year was the wood stove installed in your home? (date range between 1950-2013)

1. (open ended)
2. Don't know=9998, Refused=9999 (ask Q4 again after Q9 if DK/REF)

Q5A-B) Do you know the make and model of your wood stove?

Q5A) Make

1. (open-end)
3. Don't know / Refused (ask Q5 again after Q9 if DK/REF)

Q5B) Model
1. (open-end)
2. Don't know / Refused (ask Q5 again after Q9 if DK/REF)

Q6) If you have a wood stove and it is EPA certified, it should have an EPA-certification label on the back or side. Please take a look at it as the next questions I will ask you are specific to the information written on the label.

If the respondent refuses or is unable to see the label - ask if you can set up a call back time to speak with someone who can or a time that is more convenient – be sure to reread the list of information you will be calling back for.

If respondent refuses to set up a call back time - ask if you can send them a postcard to be returned by mail with the requested information. (GO TO Q22 IF Q2=1 or 3 only and Q6=3 (Refused-YES TO POSTCARD). IF Q2=1 AND Q6=3 (Refused-YES TO POSTCARD) GO TO Q22. IF Q2=1 & 5 AND Q6=3 (Refused-YES TO POSTCARD) GOT TO Q10)

1=Continue
2=Set callback
3= Refused (YES TO POSTCARD)
4=Refused (NOT TO POSTCARD) – terminate
5=Wood stove not EPA Certified (go to Q22 if Q2=1 only, If Q2=1, 3 & 5, go to Q3I, then DQ10)
6=Label no longer available/Unreadable ((go to Q22 if Q2=1 only, If Q2=1, 3 & 5, go to Q3I, then DQ10)

Is it Catalyst Equipped or Non Catalytic?

1. Yes
2. No
3. Don't Know / Refused

Q7)What is the Smoke Rating (grams/hour)? – (range = 0.5 – 8 grams per hour)

______ (DK=98/REF=99)

Q8)What is the Efficiency (50% - 100%)?

1. Open ended (in percent)
2. Don't know=998, Refused=999

Q9)What is the Heat Output range (Btu/Hr.)? (range = 1000-80,000 btu)

1. Open ended (defined as range in # Btu/Hr eg "7000-30000")
2. Don't know=99998, Refused=99999

[IF Q2=3. INSERT, ASK Q3I-Q9I]

INSERT SECTION

Q3I) I am going to ask you a few questions about your Insert heating device. Are you able to look at it to give me some specific information?

3. Yes
4. No (ask if there is a better time to call back)

Q4I)What year was the Insert heating device installed in your home? (date range between 1950-2013)

4. (open ended)
5. Don't know=9998, Refused=9999 (ask Q4 again after Q9 if DK/REF)

Q5AI-Q5BI) Do you know the make and model of your Insert heating device?

Q5AI) Make

1. (open-end)
6. Don't know / Refused (ask Q5AI again after Q9I if DK/REF)

Q5BI) Model
1. (open-end)
2. Don't know / Refused (ask Q5BI again after Q9I if DK/REF)

Q6I) If you have an Insert heating device and it is EPA certified, it should have an EPA-certification label on the back or side. Please take a look at it as the next questions I will ask you are specific to the information written on the label.

<u>If the respondent refuses or is unable to see the label</u> - ask if you can set up a call back time to speak with someone who can or a time that is more convenient – be sure to reread the list of information you will be calling back for.

<u>If respondent refuses to set up a call back time</u> - ask if you can send them a postcard to be returned by mail with the requested information. (GO TO Q22 IF Q2=1 or 3 only and Q6=3 (Refused-YES TO POSTCARD). IF Q2=3 AND Q6I=3 (Refused-YES TO POSTCARD) GO TO Q22. IF Q2=3 & 5 AND Q6I=3 (Refused-YES TO POSTCARD) GOT TO Q10)
1=Continue
2=Set callback
3= Refused (YES TO POSTCARD)
4=Refused (NOT TO POSTCARD) – terminate
5= Insert stove not EPA Certified (go to Q22 if Q2=3 only. If Q2=3 & 5, go to DQ10 before Q22)
6=Label no longer available/Unreadable (go to Q22 if Q2=3 only. If Q2=3 & 5, go to DQ10 before Q22)

Is it Catalyst Equipped or Non Catalytic?

4. Yes
5. No
6. Don’t Know / Refused

Q7I)What is the Smoke Rating (grams/hour)? – (range = 0.5 – 8 grams per hour)

______ (DK=98/REF=99)

Q8I)What is the Efficiency (50% - 100%)?

3. Open ended (in percent)
4. Don’t know=998, Refused=999

Q9I)What is the Heat Output range (Btu/Hr.)? (range = 1000-80,000 btu)

3. Open ended (defined as range in # Btu/Hr eg “7000-30000”)
4. Don’t know=99998, Refused=99999

[IF Q2=5 Hydronic heater, ASK Q10-Q21]

HYDRONIC HEATER SECTION

Q10) If you have a hydronic heater and it is "Phase 1 or Phase 2 Qualified", it will have a white label. Please take a look at it as the next questions I will ask you are specific to the information written on the label.

If the respondent refuses or is unable to see the label - ask if you can set up a call back time to speak with someone who can or a time that is more convenient – be sure to reread the list of information you will be calling back for.

If respondent refuses to set up a call back time - ask if you can send them a postcard to be returned by mail with the requested information. (GO TO Q22 IF Refused=Yes to Postcard, terminate if Q2=5 only and Q10=4 Refused-No to Postcard)
1=Continue
2=Set callback
3= Refused (YES TO POSTCARD)
4=Refused (NOT TO POSTCARD) – terminate
5= Hydronic heater not Phase 1/Phase 2 (go to Q22)
6= Label no longer available/Unreadable (go to Q22)

What is the Smoke Emissions This Model number (0.xx lbs/million btu)?

(IF NEEDED, read: This will be shown as a triangle along the bottom of a line. The number we are looking for is the one that says "this model")
(range = 0 - 0.5 lbs / million btu)

1. Open ended (in lbs/million Btu)
2. Don't know=98 / Refused=99

Q11)If it is not too difficult, please provide information on the following items:

Manufacturer (of the hydronic heater)
1. Open ended
2. Don't know / Refused

Q12)Model Number (of the hydronic heater)

1. ENTER MODEL NUMBER
2. Don't know / Refused

Q13)8-Hour Heat Output Rating (Btu/Hr)

- (range = 1,000-400,000 btu/hr, answer will be in a range such as "10,000-40,000"

1. Open ended (in Btu/Hr)
2. Don't know=999998, Refused=999999

Q14)8-Hour Average Efficiency (in %)

- We will set this as a numeric open-end with 0-100% range then we can code DK as 101 and REF as 102 or both with 101

1. Open ended (in %)
2. Don't know=101, Refused=102

Q15) Is your hydronic heater tag orange or white ?

1. Orange with a white border
2. White with an orange border
3. Don't know / Refused (skip to Q19)

Q16)(ask Q16 only if Q15 = 1. Orange)

What is the Average emissions in Grams per Hour? This is denoted as blank grams per hour average

- (range = 5-30 grams /hr)

1. Open ended (in GRAMS/HR)
2. Don't know / Refused

Q17)(ask Q17 – Q18 only if Q15 = 2 White)

What are the average emissions in grams per hour?

(range = 0-15 grams / hr)

1. Open ended (in GRAMS/HR)
2. Don't know=98 / Refused=99

Q18) What is the maximum test run emissions? (IF NEEDED, read: This is denoted as blank grams per hour maximum test run).

- (range = 0-20 grams/hr)

1. Open ended (in GRAMS/HR)
2. Don't know=98 / Refused=99

Q19)The next number down should be blank lbs per million BTU heat input. Can you read me that number?

- (range = 0-1 lbs/million btu)

1. Open ended (in LBS/MILLION BTU)

2. Don't know=98 / Refused=99

Q20) The next number down should be blank lbs per million BTU heat output. Can you read me that number?
- (range = 0-3 lbs/million btu)

1. Open ended (in LBS/MILLION BTU)
2. Don't know=98 / Refused=99

Q21) The last number on the bottom should read blank grams per hour per ten thousand BTU output. Can you read me that number?
- range = 0-2 grams / hr)

1. Open ended (in GRAMS/HR/10000BTU OUTPUT)
2. Don't know=98 / Refused=99

ALL DEVICE SECTION

ASK ALL

Q22)What other heating devices do you use?

1. A central oil furnace
2. Portable fuel oil or kerosene heating device
3. Toyo (toy-oh), Monitor, or other direct vent type heater
4. Natural gas heat
5. Coal heat
6. Municipal heat
7. Other (specify)
8. Don't Know / Refused
9. No other heating device (go to Q27)

ASK ALL

Q23A-Q23B)Roughly how much of your winter heating is done with wood versus other heating methods? For instance would you say you heat with 20% wood and 80% heating oil? (Should equal to 100%)

1. % Fuel oil
2. % Wood
3. DK=998
4. Refused=999

Q24) (For multi-device HHs) Do you always burn wood at colder temps as a secondary source of heat?

1. Yes
2. No
3. Don't know / Refused

Q25) Ask only if Q24 = 1. Yes, otherwise skip to Q27)

Is that because

1. You need the extra heat to keep all areas of the house warm
2. To save money?
3. Both?
4. Other specify
5. (Don't know/Refused)

Q26)(ask only if Q25 = 1. Yes, otherwise skip to Q27)
At what temperature do you have to start burning wood to keep all of the areas of the house warm?

1. Open ended (in degrees Fahrenheit) = (range: -60 to 100 degress)
2. Don't Know=998 / Refused=999

Q27)Have you participated in any of the following programs? (allow multiple responses)

1. Borough's Wood Stove Change Out Program
2. AHFC Home Rebate
3. AHFC Weatherization
4. No
5. Don't Know / Refused

(AHFC = Alaska Housing Finance Corporation)

ALL DEVICES, NEVER PARTICIPATED IN OTHER PROGRAMS SECTION

Q28) (ask only if Q27 = 4. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

If you did not participate in these programs, would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 75% of the cost of installing a new replacement device?

1. Yes
2. No
3. Don't Know / Refused

Q29) (ask if Q28= 2. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

Would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 80% of the cost of installing a new replacement device?
1=YES
2=NO
3= (Don't know/Refused)

Q30) (ask if Q29= 2. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

Would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 85% of the cost of installing a new replacement device?
1=YES
2=NO
3= (Don't know/Refused)

Q31) (ask if Q30= 2. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

Would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 90% of the cost of installing a new replacement device?
1=YES
2=NO
3= (Don't know/Refused)

Q32) (ask if Q31= 2. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

Would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 95% of the cost of installing a new replacement device?
1=YES
2=NO
3= (Don't know/Refused)

Q33) (ask if Q32= 2. No, otherwise skip to Q34, if Q2=2 Pellet, skip to Q37)

Would you change out the wood burning device you currently operate to a cleaner device if the Borough reimbursed you 100% of the cost of installing a new replacement device?
1=YES
2=NO
3= (Don't know/Refused)

Q34) Do you cut your own firewood or buy it from someone else?

1= Cut your own (go to Q37)
2= Buy it from someone else
3= Both
4= Don't Know / Refused

Q35A-Q35B) Ask if Q34 = 3. Both, otherwise skip to Q36)

How much of your wood do you buy versus cutting. For instance would you say you cut 75% and buy 25%?

1 = open ended (answer in terms of % cut / % bought)
2 = Don't know=998 / Refused=999

Q36) (ask only if Q34 = 2. Buy it from someone else, or 3. Both)

Where do you buy your firewood? Be as specific as possible as in the name of the person or company if possible.

1 = Open ended
2 = Don't Know / Refused

Q36A) What price, per cord, did you pay for wood this winter? (in $/cord of wood)

(Open ended) (99998=Don't know/99999=Refused)

Q36B) Does that price include the cost of delivery?

Yes
No
Don't know / Refused

[ASK Q37 ONLY IF Q2=1, 3-5]

ALL DEVICES, CORDWOOD SECTION

Q37) What types/species of wood do you burn? What's the share of each type? (read list)
(IF 1 type of wood only/Other type of wood – do not ask follow up question but auto code it as 100%)
Birch (x%)
Spruce (y%)
Alder (z%)
Other type of wood (a%)

Q38A) (Ask Q38A only if Q2 = 1 "wood stove", 3. "insert" , 4 . "Fireplace" or 5. "Hydronic Heater/ Outdoor wood boiler", otherwise skip to Q38B)

In cords, how much wood do you burn from October to March?

1. ________cords
2. DK=9998/Refused = 9999

ALL DEVICES, PELLETS SECTION

Q38B) (Ask Q38B only if Q2 = 2 “pellet stove”, otherwise skip to Q38C)For Pellet Stoves:

Q38) How many 40 lb bags of pellets do you burn in your wood burning stove or insert from October to March?

1. 40 lb bags of pellets ________
2. DK=9998/refused=9999

Q38C) How long do you season your wood, if at all? (range: 0 to 120 months)

(open ended) (record answer in number of months) code Don’t know as 998 and Refused as 999

Q39) Knowing that dry wood provides 25 percent more heat than wet wood, would you pay $25 more per cord for dry wood?

1 = Yes
2 = No
3 = Don’t Know / Refused

Q40) (ask if Q39 = 1. Yes, otherwise skip to Q43)

Would you pay 50 dollars more per cord for dry wood?

1 = Yes
2 = No
3 = Don’t Know / Refused

Q41) (ask if Q40 = 1. Yes. Otherwise skip to Q43)

Would you pay 75 dollars more per cord for dry wood?

1 = Yes
2 = No
3 = Don’t Know / Refused

Q42) (ask if Q41 = 1. Yes. Otherwise skip to Q43)

Would you pay 100 dollars more per cord for dry wood?

1 = Yes
2 = No
3 = Don't Know / Refused

Q43) On a scale of zero to a hundred with zero being wide open and a hundred being completely shut, where do you typically set the air damper on your wood stove or insert? (0-100% for min/max)?

Open ended (%)
Don't know=101 / Refused=102

Q44) Is there a difference between your nighttime and daytime setting?

1 = Yes
2 = No
3 = Don't Know / Refused

Q45) (Ask if Q44 = 1. Yes, otherwise skip to Q 47)

On a scale of zero to a hundred with zero being wide open and a hundred being completely shut, where do you set your air damper at night?

1. Open ended (%)
2. Don't know / Refused

Q46) (Ask if Q44 = 1. Yes, otherwise skip to Q 47)

On a scale of zero to a hundred with zero being wide open and a hundred being completely shut, where do you set your air damper during the daytime?

3. Open ended (%)
4. Don't know / Refused

Q47) If natural gas becomes available in Fairbanks, What natural gas price would get you to stop burning wood? This is a little bit difficult, but if you could, please phrase it in terms of dollars per gallon of heating fuel. For example you could say I would stop burning wood if natural gas cost the equivalent of four dollars a gallon of heating oil, or three dollars a gallon, etc.

1. Open ended (in $/GALLON) (range: 0-20 dollars)
2. Don't know / Refused

Q48) If natural gas were available in Fairbanks, would you still need to burn wood at lower temperatures to keep your house warm regardless of how gas is priced?

1. Yes
2. No
3. Don’t know / Refused

IF RESPONDENT AGREED TO BE SENT A POSTCARD IN Q6, Q6I OR Q10, ASK the following information before terminating the call:

Name to send the Postcard to (full name)
Full Address

(END)
Those are all the questions I have today. Thank you for your time and participation. Have a good day/evening.

2013 Fairbanks Wood Purchasing Survey Questionnaire

Hello, this is ___________ calling from Hays Research Group, an Alaskan research firm. We are conducting a survey today on behalf of the State and The Fairbanks Northstar Borough to gather information about house heating devices to help us better understand the air quality issues in the area. Your number was selected at random, and all information collected will be kept confidential, your name address and phone number will not be included in any of the information given to the State or Borough. Can I speak to the person in the household who would be most knowledgeable about heating methods in your home?

Q1)Do you use any wood-burning heating devices in your house during the winter?

1. Yes (continue)
2. No (end call)

Q2)What type of wood device(s) do you use? Read list (allow multiple responses)

1. Stove
2. Insert
3. Fireplace
4. Hydronic heater (also known as an outdoor wood boiler)
5. Other (specify)
6. Don't know / Refused

Q3)Do you cut your own firewood, or buy it?

1. Cut
2. Buy
3. Both
4. Don't Know / Refused

Q4) (ask only if Q3 = both) How much of your wood do you buy versus cutting. For instance would you say you cut 75% and buy 25%?

1. open ended (answer in terms of % cut / % bought)
2. Don't know / Refused

PURCHASED WOOD (WOOD BUYERS) SECTION

Q5) (ask only if Q3 = 2. Buy, or 3. Both, otherwise skip to Q14) Regarding the firewood you purchase, do you have the wood delivered or do you pick it up?

1. Delivered
2. Pick It Up
3. Both
4. Don't know / Refused

Q6)Do you have a consistent firewood supplier?

1. Yes
2. No
3. Don't know / refused

Q7) (ask Q7 only if Q6 = 1. Yes, otherwise skip to Q09) How many years have you bought wood from them?

1. 1 year
2. 2 years
3. 3 years
4. 4 years
5. 5 years
6. 6 years
7. 7 years
8. 8 years
9. 9 years
10. 10 or more years
11. Don't know / Refused

Q8)What do you like most about the supplier? (multiple responses OK)

1. Price
2. Reliability
3. Honesty
4. Wood is split
5. Wood is dry
6. Delivery (when and where you want it dumped)
7. Other (please specify)
8. Don't know / Refused

Q9) (ask Q9 only if Q6 = 2. No, or 3, Don't know / Refused, otherwise skip to Q10) How do you choose a firewood supplier?

1. Advertisement (e.g., newspaper, Craigslist, etc.)
2. Word of mouth
3. Review old supplier info
4. Other (describe)
5. Don't know / Refused

Q10)Is the wood you buy already split or in the round?

1. Split
2. In the round
3. Both
4. Don’t know / Refused

Q11)(ask Q11 only if Q10 = 2. In the round, or 3. Both, otherwise skip to Q12)

If the wood is in the round, when do you split it? (READ OPTIONS)

1. As needed
2. Upon delivery
3. Don’t know / Refused

Q12)Do you know where your suppliers are getting their wood from?

1. Yes
2. No
3. Don’t know / Refused

Q13)Where do they get their wood from?

(OPEN ENDED)

Q14) Are you aware of firewood theft?

1. Yes (from newspaper and news articles)
2. Yes (from personal experience)
3. No
4. Don’t know / Refused

Q15) Do you ask suppliers what the moisture content of the firewood is that they are selling?

1. Yes
2. No
3. Don’t know / Refused

Q16)Do the suppliers tell you the moisture content of the firewood they are selling?

1. Yes
2. No
3. Don’t know / Refused

Q17)(ask Q17, only if Q16 = yes, otherwise skip to Q18)

Are they truthful about the moisture content when they tell you? Is it as dry as they say it is?

1. Yes
2. No
3. Don't Know / Refused

Q18)(Ask Q18 only if Q5 = 1. Yes, or 3. Both, otherwise skip to Q19)What is the delivery fee you pay for your wood? This is not the price of the wood, but only the delivery charge.

1. $__
2. Don't Know / Refused

CUT WOOD (WOOD BUYERS) SECTION

Q19) (ask Q19 only if Q3 = 1. Cut, or 3. Both, otherwise skip to Q20) With regard to the wood that you cut, where do you cut it (read list) (accept multiple answers)

1. State Lands
2. Military Bases
3. Railroad Land
4. Personal Property
5. Other (Please specify)
6. Don't Know / Refused

Q20)How long do you season your wood, if at all?

(open ended) (record answer in number of months)

Q21) (ask Q21 only if Q3 = 2. Buy or 3. Both, otherwise survey is complete)

What price did you pay for your wood this winter per cord? ($/cord)?

Q22) Knowing that dry wood provides 25 percent more heat than wet wood, would you pay $25 more per cord for dry wood?

1. Yes
2. No
3. Don't Know / Refused

Q23)(Ask Q23 if Q22 = 1. Yes, otherwise survey is complete)

Would you pay 50 dollars more per cord for dry wood?

1. Yes
2. No
3. Don’t Know / Refused

Q24)(Ask Q24 if Q23 = 1. Yes, otherwise survey is complete)

Would you pay 75 dollars more per cord for dry wood?

1. Yes
2. No
3. Don’t Know / Refused

Q25)(Ask Q25 if Q24 = 1. Yes, otherwise survey is complete)

Would you pay 100 dollars more per cord for dry wood?

4. Yes
5. No
6. Don’t Know / Refused

(END OF SURVEY)

Attachment B

FMATS Regional Travel Demand Modeling Documentation

MEMORANDUM

TO: FMATS

FROM: MING S. LEE

SUBJECT: FMATS TRAVEL DEMAD MODEL BASELINE CALIBRATION REPORT FOR CENSUS 2010 UPDATE

DATE: 6/30/2011

CC:

Attached with this memo is the calibration report for the FMATS model update with 2010 Census data.
Please let me know if you have any questions, comments and suggestions for the model work. I appreciate the opportunity of working on the model for FMATS.

The Fairbanks Metropolitan Area Transportation System (FMATS) Travel Demand Forecasting Model Update with Census 2010 Data

2010 Base Model Calibration Report

June 30, 2011

Prepared by

Ming S. Lee, Ph.D.

for

The Fairbanks Metropolitan Area Transportation Systems

Introduction

This report documents the calibration of the 2010 baseline model for the Fairbanks Metropolitan Area Transportation System (FMATS) Travel Demand Forecasting (TDF) model. The model is updated with 2010 Census data and the most recent employment data for the model area. This updated 2010 baseline model is calibrated to traffic volume data from the 2009 (i.e., the most recent) traffic volume report of the Northern Region of Alaska Department of Transportation. In addition, the truck traffic component of the model is also calibrated with additional truck traffic data that are available with 2009 volume report.

Materials presented in this calibration report highlight the technical details and calibration results of the newly calibrated model.

Passenger Traffic Model Structure Overview

The conventional 4-step TDF model predicts and forecasts passenger vehicle traffic (i.e., passenger vehicles used for commuting to work, shopping, and other personal and household-related matters). Heavy vehicles that are used for commercial purposes are typically modeled separately.

A passenger TDF model divides the modeling area into Traffic Analysis Zones (TAZ), and each TAZ has household and employment data identified for the purpose of trip generation. This household and employment data are used by the model to predict trip productions and attractions for each individual zone. For modeling purposes, the TAZs are connected by a computerized planning network that is defined by links and nodes, representing the actual roads and intersections in the area. Each roadway link is defined by specific data that generally include roadway length, travel speed, number of lanes, roadway capacity.

The updated FMATS TDF model continues to use the traditional four-step modeling process. These steps are technically described in the Institute of Transportation Engineers (ITE) Transportation Planning Handbook, 2nd edition (page 188). In more general terms these steps are as follows:

1. Trip Generation – This step predicts the number of person trip ends that are generated by and attracted to each defined zone in a study area. This results in a table of Productions & Attractions for each zone.
2. Trip Distribution – This step connects trip ends estimated in the Trip Generation process to determine number of trip interchanges between each zonal pair. This results in a Trip Table matrix that quantifies the number of trips that will travel between one zone and all other zones.
3. Mode Choice – This step allows the model to consider different travel modes (vehicles, transit, bicycle, pedestrian, etc) used for each zonal interchange. For many large urban areas, transit is an important factor; however for Fairbanks, transit and other modes make up a very small percentage of the total daily trips. The FMATS model only considers vehicle trips, and the mode choice step is skipped.

4. Trip Assignment – This step assigns zone-to-zone trips to specific travel routes, generally based on factors such as the fastest total travel time. Typically, before assignment, all the 24 hour vehicle travel demands will be distributed to different time periods (e.g., AM peak, PM peak, and off-peak) during the day. The sum of all trips for each link during a particular time period is then calculated as the estimated traffic volume on that link. The model is able to adjust travel speeds and add delays on roadway facilities that are more heavily used. If necessary, the model reassigns trips to less congested travel routes, in an effort to simulate every day travel choices that drivers make in the real world.

Model Coverage Area

The current FMATS TDF model covers FMATS' $PM_{2.5}$ non-attainment area (i.e., the dash line in Figure 1). The green boundary lines in Figure 1 are the TAZ boundaries that were designed to cover the entire $PM_{2.5}$ non-attainment boundary. The road network (i.e., the blue lines) also covers the entire $PM_{2.5}$.5 non-attainment area.

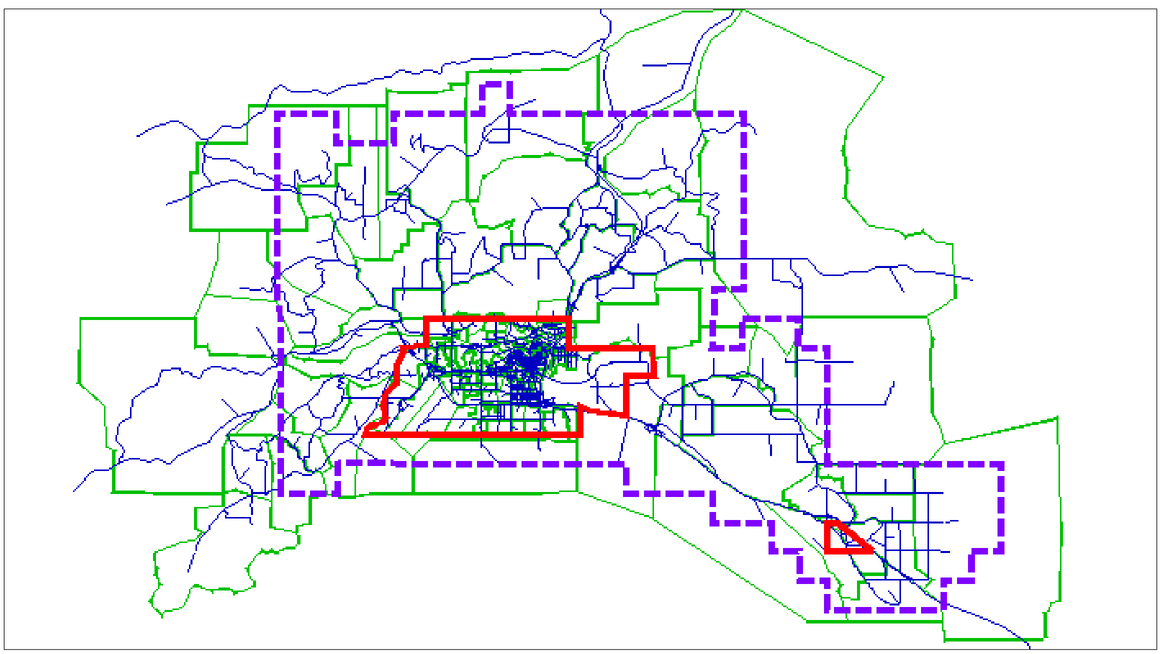

Figure 1. The Expanded FMATS Model Area

TAZ Data Update

The updated FMATS model maintains the same 179 TAZs used in the model for FMATS 2035 LRTP conformity analysis conducted in 2010. Two major pieces of TAZ information critical to trip generation modeling are the number of households and the number of employment in each TAZ. Both household and employment numbers in the TAZs are updated with the most recent data.

Household data are updated with 2010 Census Redistricting data for the State of Alaska that became available in March 2011. The Redistricting data were first downloaded from the US Census web site. Census Block level data pertaining to the Fairbanks North Star Borough (FNSB) were then extracted. Note that the Census Restricting data released in March 2011 only contain the numbers of housing units (i.e., both occupied and vacant) in each Census Block. Other household data (e.g., number of cars and number of persons in each houshold) in each Census Block had not been released by the time this model calibration was completed.

The FMATS TAZs were then superimposed on top of the Census Blocks (see Figure 2). A total of 33,873 occupied housing units was identified in the areas covered by the FMATS model TAZs. For each TAZ, the total number of occupied housing units within the TAZ is identified by adding together all the occupied houses of all Census Blocks within the TAZ. Note that vacant housing units were not counted for each TAZ, because without occupants there would be no trips generated.

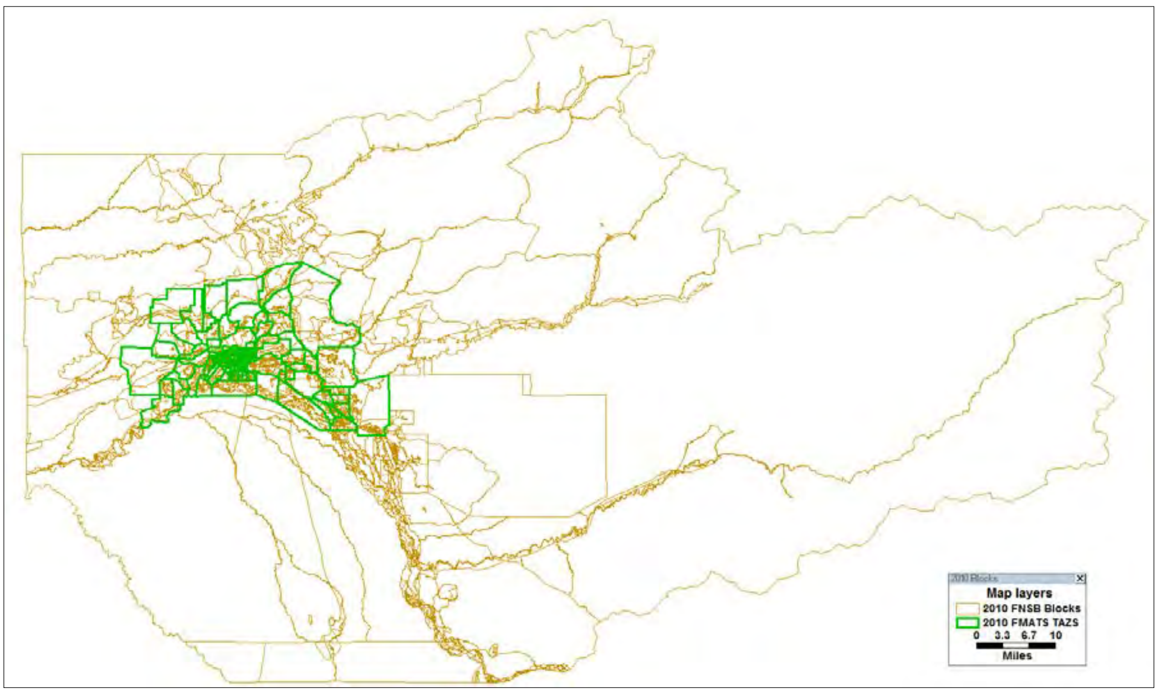

Figure 2 FMATS TAZ on top of 2010 Census Blocks

The employment data for TAZs are derived from the most recent InfoUSA business data purchased for FNSB and the cities of Fairbanks and North Pole. The business data include all businesses in the area. The InfoUSA data identify the types, the locations, and the numbers of employees of the businesses. The data are used to calculate the number of employees by types (i.e., retail, service, and other) in each TAZ. By the time the data were purchased in April 2011, the database was properly updated and encompasses all the employments that existed by the end of 2010.

The identified businesses were geo-coded. For each TAZ, the total number of employment within the TAZ is identified by adding together all the employment of all businesses within the TAZ. A total of 47,191 occupied housing units was identified in the areas covered by the

FMATS model TAZs. Of all employments, there are 7,662 retail employments, 17,884 service employments, and 21,645 other employments that are not retail or service.

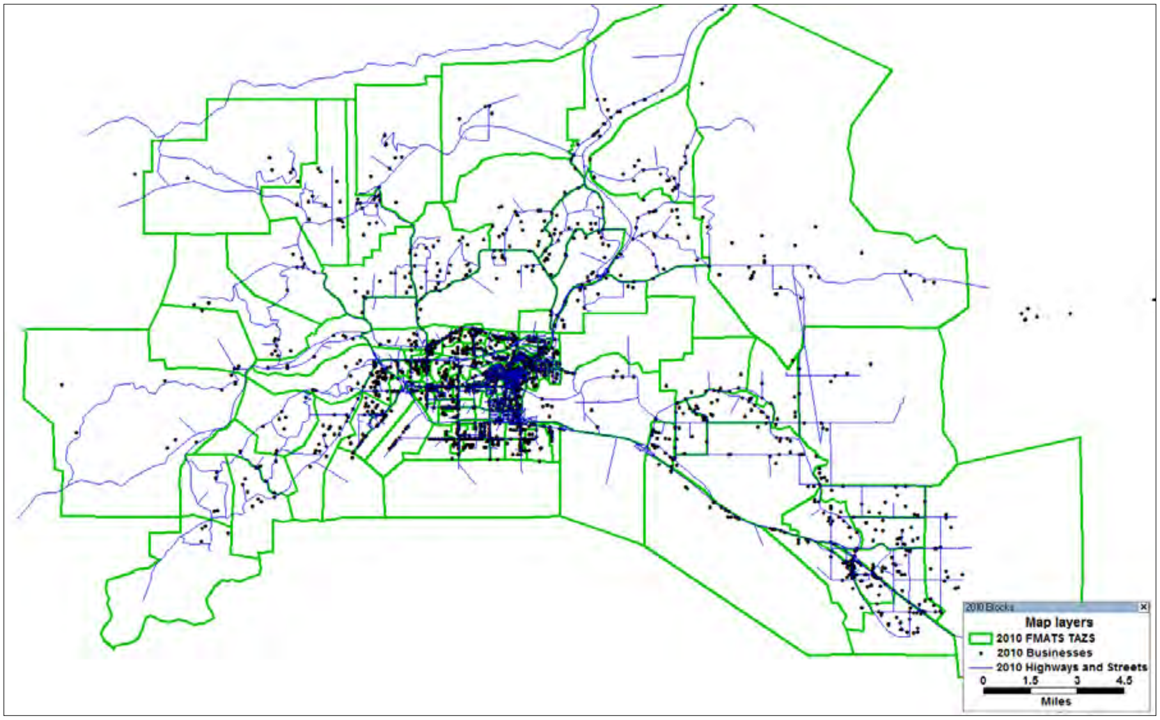

Figure 3 Business Locations in the FMATS Area

Special Generators Employment Data

UAF, Fort Wainright, Fairbanks Airport, and the Fairbanks Memorial Hospital are the 'special generators' in the updated model. These four establishments generate significant amount of traffic and estimation of the number of trips coming in and out of the establishment requires special attention to ensure the reasonableness of the model. For the four special generators, the numbers of employment are taken from the *Fairbanks North Star Borough Community Research Quarterly, Spring 2008*. These numbers are used because they are accurately compiled with local knowledge.

Trip Generation Update

Trip Production

After the preparation of the household and employment data for each TAZ, trip production and attraction is calculated for all TAZs and external stations. The methodology for trip production and attraction calculation is the same as the previous model.

For trip generation, the updated model follows the NCHRP report 365: Travel Estimation Techniques for Urban Planning. The basic trip production and attraction equations and rates from the report 365 are used. Trip production rates in Table 1 are used to calculate the number of person trip produced by a household with a particular number of persons and vehicle ownership in the household.

It is important to note that only the total number of households (i.e., occupied housing units) are available from the first release of the 2010 Census Redistricting data for Alaska. In order estimate the number of households with particular number of cars and persons, it was assumed that within each TAZ the proportions of households by auto ownership groups and household size groups remain the same as the previous model update. The 2010 total number of households for each TAZ is then multiplied with the proportions to arrive at the number of households by auto ownership and household size groups.

Table1: Trip Production Rates.

Production Rates (person trips/household)		**Number of persons in the household**				
		1	**2**	**3**	**4**	**5+**
Number of vehicles in the household	**0**	2.6	4.8	7.4	9.2	11.2
	1	4.0	6.7	9.2	11.5	13.7
	2	4.0	8.1	10.6	13.3	16.7
	3+	4.0	8.4	11.9	15.1	18.0

The calculated person trips are then divided into 3 trip purposes with the following proportions:

- Home-Based Work (HBW): 20%
- Home-Based Non-work (HBNW): 57%
- Non Home-Based (NHB): 23%

The numbers of trips by the three purposes calculated for all the households within a TAZ will then be aggregated as the numbers of trip production of the TAZ.

Trip Attraction

For trip attraction estimation, the employment data prepared for each TAZ are applied with the trip attraction rates in Table 2 to determine the number of person trip attraction by trip purposes.

Table2: Trip Attraction Rates.

Attraction Rates (Person Trips)	HBW	HBNW	NHB
Total Employment	1.45	0	0
Retail Employment	0	9.0	4.1
Service Employment	0	1.7	1.2
Other Employment	0	0.5	0.5
Total Households	0	0.9	0.5

The numbers of trips attraction by the three purposes calculated for all the businesses within a TAZ are then aggregated as the numbers of trip attraction of the TAZ.

External Station Production and Attraction

The locations of the external stations of the model are shown in Table 3.

The method for estimating the production and attraction for the 7 external stations used in the previous models are retained. That is, a certain percentage of the traffic counts at a external station is subtracted to be the external-external trips (i.e., trips that go through the modeling area without stopping). Table 3 shows the traffic counts used for the external stations and the percentages of traffic counts used for the external-to-external trips. The traffic counts are obtained from the Northern Region of the Alaska Department of Transportation and Public Facilities.

Table 3 Year 2007 External Station Traffic Counts

External Station Number	External Station	Traffic Count (vehicles)	% External – External (E-E)	E-E trips
1	SHEEP CREEK ROAD AT GOLDSTREAM CREEK BRIDGE	2602	1.00%	26
2	BALLAINE ROAD SOUTH OF GOLDSTREAM ROAD	4411	1.00%	44
3	CHENA HOT SPRINGS ROAD WEST OF NORDALE ROAD	2209	1.00%	22
4	OLD STEESE HIGHWAY SOUTH OF STEESE EXPRESSWAY	2922	1.00%	146
5	STEESE EXPRESSWAY NORTH OF GOLDSTREAM RD (SHRP SITE)	10819	1.00%	541
6	RICHARDSON HIGHWAY AT MOOSE CREEK	2600	5.00%	26
7	PARKS HIGHWAY AT ESTER	2365	5.00%	24

The remaining traffic counts are then covered to external-to-internal trip production and attraction of the three purposes using the following conversions factors taken from NCHRP report 365:

- HBW: 20%
- HBNW: 57%
- NHB: 23%.
- 1.11 persons per vehicle for HBW
- 1.67 persons per vehicle for HBNW
- 1.66 persons per vehicle for NHB.

External to External Vehicle Trips

The external station traffic counts subtracted for external-to-external trips are transformed to a external-to-external vehicle trip table using the Fratar method, which is a technique to fill the cells of a trip table for which we have targets for the row sums and column sums (i.e., the number of external-to-external trips at each external station).

Table 4 shows the completed external-to-external vehicle trip table. This table is further divided into three time periods, AM peak for 7 to 9 am, PM peak for 3 to 6 pm, and off-peak for all remaining hours, using factors for percent of HBW vehicle trips (i.e., external to external trips are mostly work related) by hour by trip purpose found in NCHRP report 365.

Table 4 External to External Vehicle Trip Table Produced with the Fratar Method

	1	2	3	4	5	6	7	Estimated Row sums	Target
1	0	0	0	0	0	0	0	0	0
2	0	0	1	4	7	4	6	22	22
3	0	1	0	1	9	1	1	13	13
4	0	4	1	0	6	5	0	16	16
5	0	7	9	7	0	2	3	28	28
6	0	4	0	5	2	0	0	11	11
7	0	6	1	0	3	0	0	10	10
Estimated Column Sums	0	22	12	17	27	12	10		
Target (E-E trips at a station_)	0	22	12	17	27	12	10		

Each of the three period external-to-external vehicle trip tables will be added to the corresponding time-of-day vehicle trip table after the time-of-day modeling.

Production and Attraction Adjustment

The estimated production and attraction of all the TAZs are then used to carry out rest of the modeling steps. Results after trip distribution and traffic assignment suggested that adjustments need to be made to the original NCHRP production and attraction rates in order for the model outputs to match observed data. Details of the production and attraction adjustment are described in Trip Distribution Update and Traffic Assignment Update.

Trip Distribution Update

The expanded FMATS TDF model adopts the Gravity Model with Friction Factors for trip distribution. The model structure and un-calibrated friction factor values are again taken from NCHRP report 365. The advantage of the method is that it allows for the number of trips between TAZs to be calibrated by different travel time length, thus allowing for better matching with the observed commuting time data from American Community Survey (ACS) data.

The ACS is also conducted by the U.S. Census Bureau. This survey uses a series of monthly samples to produce annually updated data for the same small areas (census tracts and block groups) as the decennial census long-form sample formerly surveyed. Initially, five years of samples are required to produce these small-area data. Once the Census Bureau has collected five years of data, new small-area data are produced annually.

For travel demand forecasting purposes, ACS offers data on commuters by travel time to work. Based on the recent ACS data, 39,164 workers commuted to jobs in FNSB, taking on average 17.3 minutes each way.

Detailed breakdown of the travel time to work data by 5 minute increments is shown in Table 5.

Table 5 ACS Percent of Commuters by Travel Time to Work

Commuting Time	Number of commuters	Percent

		of Total
Less than 5 mins.	1,817	4.6%
5 to 9 mins.	5,586	14.3%
10 to 14 mins.	8,242	21.0%
15 to 19 mins.	9,417	24.0%
20 to 24 mins.	6,947	17.7%
25 to 29 mins.	1,146	2.9%
30 to 34 mins.	2,659	6.8%
35 to 39 mins.	386	1.0%
40 to 44 mins.	1,078	2.8%
More than 45 mins.	1886	4.8%
Total number of commuters (to work)	39,164	100.0%

The calibration of the gravity model began with a set of initial friction factors found in NCHRP Report 365. The calibrated gravity model produces a set of friction factors and trip distribution results that are comparable to the ACS data. For HBW trips (i.e., commuting to work), the average model trip length is approximately 16 minutes, which is 1 minute shorter than the ACS value. The reason for the difference is due to the fact that the model uses external stations to represent travel origins and destinations for trips in and out of the FMATS area. In reality, some commuters reported to the ACS travel time for up to 90 minutes, which is beyond the longest travel time within the model boundary. Despite the small difference in average commuting time, the model produces a breakdown of percent of trips by travel time (Table 6) that closely resemble the ACS data. Figure 4 and 5 show the histograms of the ACS and FMATS model percentages of trips by travel time. The figures show that, other than trips in large travel time increments (45 minutes and beyond), the updated gravity model matches the frequency patterns of the ACS.

Table 6 Updated FMATS Percent of HBW Trips by Travel Time Increments

Travel Time for HBW Trips	ACS Percentages	Model Number of Person Trips	Model Percentages	Difference between Model and ACS
Less than 5 mins.	4.6%	2767	6%	1.1%
5 to 9 mins.	14.3%	5984	13%	-1.8%
10 to 14 mins.	21.0%	10665	22%	1.2%
15 to 19 mins.	24.0%	15782	33%	8.9%
20 to 24 mins.	17.7%	8133	17%	-0.7%
25 to 29 mins.	2.9%	1684	4%	0.6%
30 to 34 mins.	6.8%	2264	5%	-2.1%
35 to 39 mins.	1.0%	263	1%	-0.4%
40 to 44 mins.	2.8%	229	0%	-2.3%
More than 45 mins.	4.8%	77	0%	-4.7%
Total	**100.0%**	47848	100%	**RMSE = 3.4%**

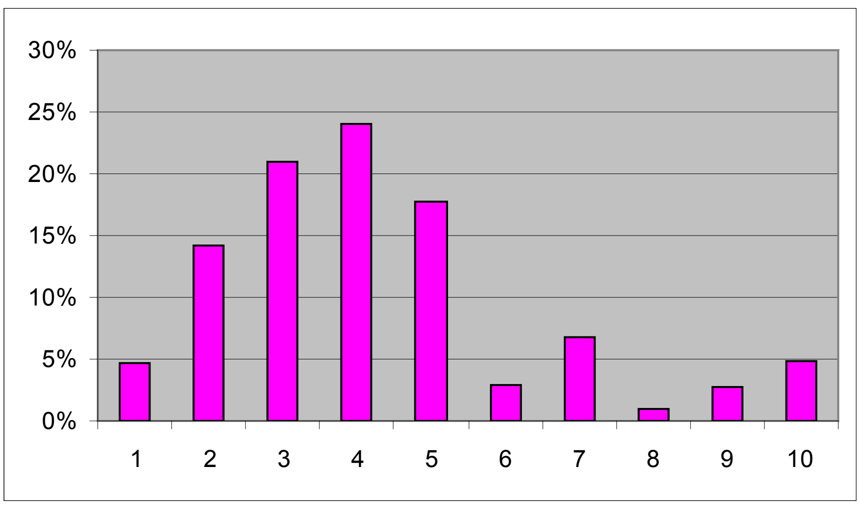

Figure 4 ACS Percent Commuter by Travel Time to Work

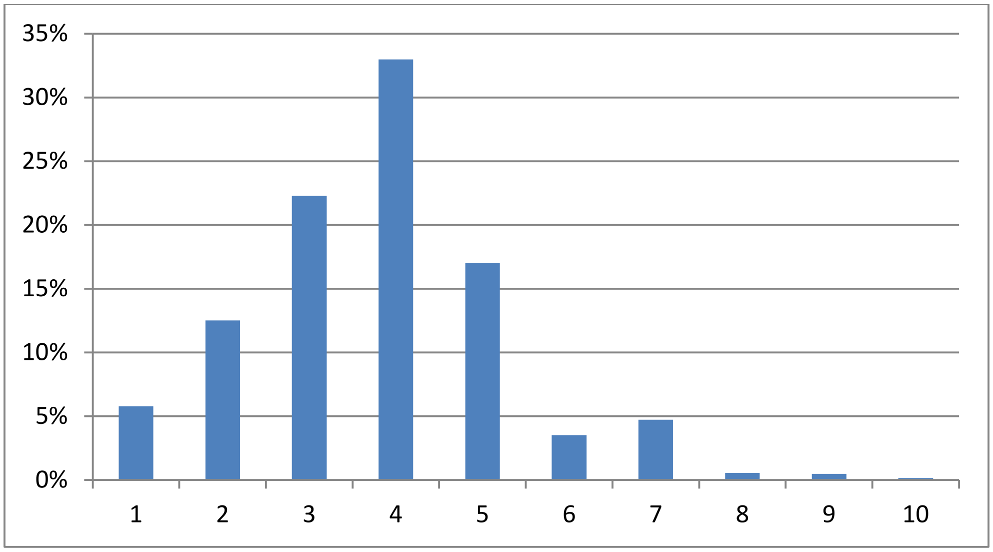

Figure 5 Model HBW Trip Length Frequency Distribution

During the trip distribution calibration, the original HBW production number derived with the NCHRP trip rates is found to be larger than 39,164, the total number of commuter trips. The first adjustment made to the TAZ production and attraction is to factor down the HBW production and attraction such that the total number of HBW production and attraction each equals 39,164.

Time-of-Day Modeling

The time-of-day model adopted for the FMATS TDF model 'spreads' the 24 hour person trips (i.e., product of trip distribution) to person trip in different time periods (i.e., AM peak for 7 to 9 am, PM peak for 3 to 6 pm, and off-peak for all remaining hours). The person trips of different time periods are then applied with vehicle occupancy factors to arrive at AM, PM, and off-peak vehicle trip tables, each a required input to the traffic assignment process.

The factors used to spread the trips to different time of the day are initially derived from the NCHRP report. The factors are then calibrated to local conditions based on observed traffic patterns (i.e., many HBW trips in the FNSB area starts as early as 6 am) and a trial and error process that involving numerous calibration runs to match the model link volumes to traffic counts of different time periods. The calibrated time-of-day factors are shown in Table 7.

Table 7 Calibrated Time of Day Factors

HOUR	HBW Departure Percentage	HBW Return Percentage	HBNW Departure Percentage	HBNW Return Percentage	NHB Departure Percentage	NHB Return Percentage
0	0	0.4	0	0.5	0.15	0.15
1	0	0.2	0	0.4	0.1	0.1
2	0	0.3	0	0.5	0.1	0.1
3	0.3	0.3	0	0.3	0.05	0.05
4	1	0.1	0.1	0	0.05	0.05
5	3	0.1	0.2	0	0.05	0.05
6	5	0.2	1	0.2	0.2	0.2
7	7	0.6	1.5	0.4	0.55	0.55
8	8	0.4	2.5	0.8	0.8	0.8
9	5	0.3	5	0.9	3	2
10	4	0.5	6	1.5	4	3
11	3	1	5	3.4	4.9	4
12	3	2	5	3.8	5.5	5.8
13	2	2	4	4	5	7.5
14	1	3	3.8	4.5	4.5	7
15	1	6	4	4.8	4	4
16	1	8	3	3.5	3.5	3
17	2	9	2	3	3	2
18	1	5.8	2	3.7	3.25	3
19	1	3	2.1	3.6	2.65	2
20	0.6	2	1.5	3.5	1.85	1.85
21	0.5	1.8	0.9	3.3	1.45	1.45
22	0.3	1.5	0.3	1.9	0.75	0.75
23	0.3	1.5	0.1	1.5	0.6	0.6
Total	50	50	50	50	50	50

Person Trips to Vehicle Trips

The same vehicle occupancy factors taken from the NCHRP report to convert external station production and attraction are again used here:

- 1.11 persons per vehicle for HBW
- 1.67 persons per vehicle for HBNW
- 1.66 persons per vehicle for NHB.

These factors are applied to the person trips of different time periods. Three vehicle trip tables are derived after the person trip to vehicle trip conversion: AM peak for 7 to 9 am, PM peak for 3 to 5 pm, and off-peak for the remaining hours.

Finally, each of these vehicle trip tables will be added with the external-to-external vehicle trip table of the same period to form complete period vehicle trip table for traffic assignment.

Traffic Assignment Update

For AM and PM peak hours, the updated FMATS model uses User Equilibrium (UE) assignment method that takes into consideration of roadway capacity and the effects of congestion on drivers' route choices. For off-peak hours, incremental assignment method that is less sensitive to congestion is used, since congestion during the off-peak hours is less likely to occur.

Truck Traffic Modeling

To model truck traffic on the roads in the modeling area, truck percentage data (i.e., the percentage of truck traffic of total vehicle traffic) are taken from the 2009 traffic volume report published by the Northern Region of AK DOT & PF, which classifies motor vehicles into 13 classes (see Table 8). Classes 1 to 3 are considered passenger vehicles. The truck percentage data include classes 4 to 13.

Table 8 Northern Region AK DOT & PF Vehicle Classification

Single Unit

Class 01: Motorcycles
Class 02: Automobiles, Automobiles with trailers
Class 03: Pick up Trucks, Pick up Trucks with Trailers
Class 04: Buses (2 or 3 axles)
Class 05: Delivery Trucks, Recreational Vehicles, Dump Trucks (2 axles, 6 Tires)
Class 06: Dump Trucks, Recreational Vehicles (3 axles)
Class 07: Concrete Trucks, Fuel or Propane Delivery Trucks (4 or more axles)

Single Trailer

Class 08: Tractor/Truck with Trailer (2 axles, 6 tires)
Class 09: Tractor/Truck with Trailer (3axles)
Class 10: Tractor/Truck with Trailer (4 or more axles)

Multi- Trailer

Class 11: Tractor/Truck with 2 Trailers (5 axles)
Class 12: Tractor/Truck with 2 or more Trailers (6 axles)
Class 13: Tractor/Truck with 2 or more Trailers (7 or more axles)

It is noted that the 2009 volume report from AK DOT includes more roads with truck fractions than previous annual volume report. Figure 6 shows the locations of the roads with truck traffic percentage data.

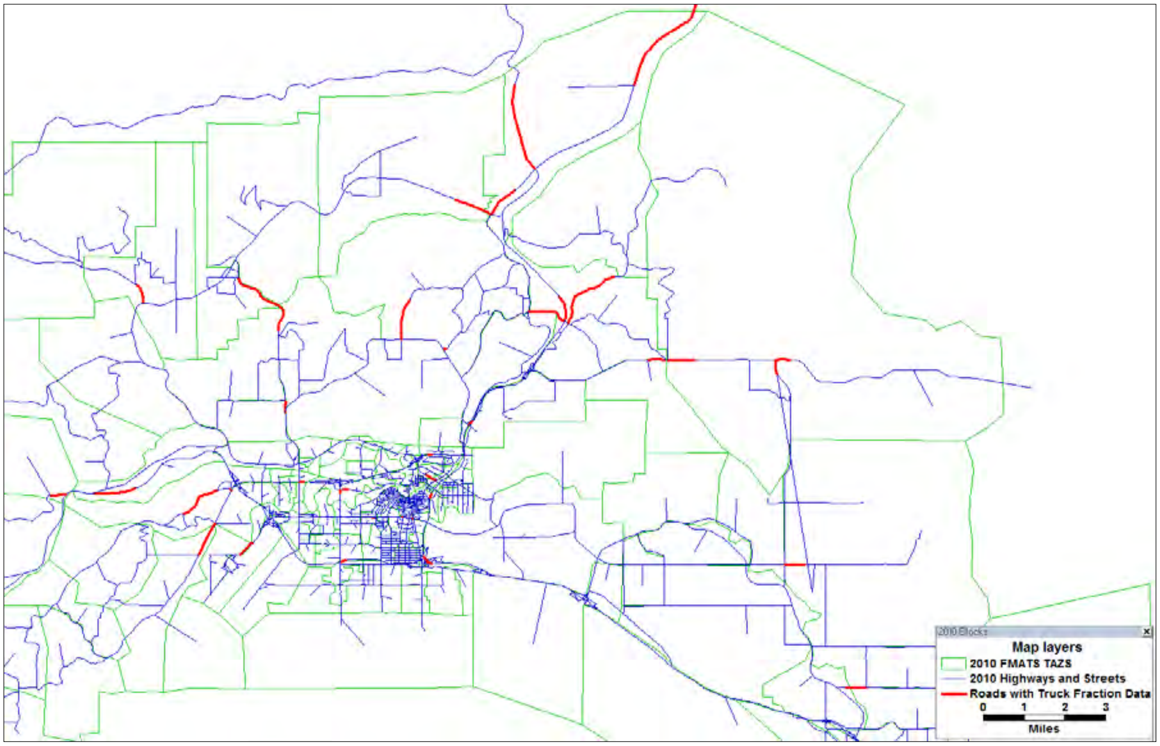

Figure 6 Truck Percentage Data

Because the number of roads with truck traffic counts in the FMATS area is small compared to the total number of links (i.e., 37 counting stations within the FMATS $PM_{2.5}$ non-attainment area), the data are extrapolated with the assumption that the same truck percentage carries over a corridor. Truck traffic fraction assumptions were made for particular links generally based on the closest links with counted fractions.

With the extrapolated truck traffic counts, the Origin-Destination (O-D) matrix estimation method in TransCAD was used to estimate the modeling area's truck O-D matrix, which contains truck traffic flows (most frequently, vehicle flows) from every origin TAZ to every destination TAZ. The O-D matrix estimation method is essentially an optimization problem, which attempts to find the most likely O-D matrix that will produce the link traffic estimates matching observed traffic counts on the given links. The resultant truck O-D matrix is assigned in the traffic assignment stage to produce link truck traffic estimates.

Table 9 shows the results of truck traffic estimation. The roads included in the table are those that have truck percentage data in the 2008 DOT volume report.

Table 9 Results of Truck Traffic Modeling

Roads	ADT 2009	2009 Truck Percent	2009 Truck	Modeled Truck	Error
AIRPORT WAY	18510	0.03	555	584	29
AIRPORT WAY	20010	0.03	600	492	-108
AIRPORT WAY	17910	0.04	716	649	-67
JOHANSEN EXPY	20945	0.05	1047	1287	240
STEESE HWY	23990	0.06	1439	785	-654
RICHARDSON HWY	19240	0.07	1347	1319	-28
STEESE HWY	15150	0.06	909	808	-101
STEESE HWY	4700	0.08	376	462	86
COLLEGE RD	19404	0.04	776	581	-195
PEGER RD	14875	0.07	1041	911	-130
CHENA PUMP RD	7842	0.07	549	501	-48
PHILLIPS FIELD RD	4495	0.06	270	252	-17
PLACK RD	2915	0.05	146	117	-29
NORDALE RD	1845	0.07	129	95	-34
CHENA HOT SPRINGS RD	3285	0.06	197	212	15
CHENA HOT SPRINGS RD	4015	0.05	201	280	79
SKYLINE DR	930	0.07	65	54	-11
BALLAINE RD	4625	0.03	139	169	30
ROBERT MITCHELL EXPY	13285	0.07	930	677	-253
PEEDE RD	995	0.05	50	68	19
GEORGE PARKS HWY	5765	0.13	749	676	-73
SUMMIT DR	1710	0.06	103	96	-7
RICHARDSON HWY	6305	0.15	946	921	-25
JOHANSEN EXPY	18705	0.1	1871	1448	-423
Goldstream Rd	1045	0.12	125	78	-48
ELLIOT HWY	1080	0.18	194	181	-13
STEESE HWY	850	0.13	111	109	-2
CHENA HOT SPRINGS RD	5230	0.05	261	230	-31
CHENA RIDGE RD	4145	0.07	290	193	-98
CHENA RIDGE RD	2450	0.07	172	196	25
BALLAINE RD	2790	0.04	112	140	28
				RMSE	**166**

Calibration Results of the Passenger Traffic Model

For link volume calibration, the new model uses more screen lines than those used in the previous model calibration. The additional screen lines essentially cover the $PM_{2.5}$ non-attainment area that is outside of the MPO boundary. Screen lines are imaginary boundaries between areas in a model network at which summary comparisons of simulated and observed traffic volumes are compared. They are useful for evaluating distribution patterns. It is important note that traffic volumes used for the screen line links are derived from the 2009 traffic volume report published by AK DOT & PF. Compared with traffic volumes from a previous year (i..e, 2006, 2007, or 2008), the total screenline traffic volume decreased in 2009. Table 10 shows the results of the calibration of the passenger counts.

Table 10 Screenline Calibration Results

North – South Screenline (West Side Fairbanks)

Link ID	*Link Description from Model*	*2009 Ground Count*	*Passenger Count**	*Truck Count*	*Passenger Model*	*Error***	*%Error*	*FHWA Target****
1370	College (Westwood)	8395	8143	252	7484	-659	-8%	25%
414	Johansen (E of University)	20945	19898	1047	20717	820	4%	15%
1097	Airport Way (E of University)	14885	14290	595	14635	345	2%	25%
587	Davis (E of University)	4515	4154	361	3470	-684	-15%	50%
415	Mitchell (E of University)	12485	11611	874	10535	-1077	-9%	20%
668	Van Horn (E of University)	570	513	57	426	-87	-15%	200%
2005	Goldstream Rd	1800	1584	216	1447	-137	-8%	100%
1136	FARMERS LOOP RD	6055	5692	363	5833	142	2%	25%
	Total	**69650**	**65884**	**6150**	**64547**	**-1337**	**-2%**	

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North - South Screenline (Central Fairbanks)

Link ID	*Link Description from Model*	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
565	College (W of Aurora)	8330	8080	250	7582	-498	-6%	25%
1874	Johansen Aurora Jct	20855	19395	1460	19529	134	1%	15%
723	Phillips Field (E of Peger)	4495	4225	270	4446	221	5%	50%
363	Airport Way (Lathrob)	17910	17194	716	15741	-1452	-8%	20%
588	Davis (E of Peger)	5315	4890	425	4068	-821	-15%	25%
1165	Mitchell (E of Peger)	13285	12355	930	11085	-1270	-10%	20%
669	Van Horn (E of Peger)	5240	4716	524	3799	-917	-17%	25%
1605	FARMERS LOOP RD	4495	4225	270	3266	-959	-21%	50%
1900	Goldstream Rd	1045	920	125	843	-76	-7%	100%
	Total	**80970**	**76000**	**6402**	**70361**	**-5639**	**-7%**	

North – South Screenline (East Side Fairbanks)

Link ID	*Link Description from Model*	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
563	College (Margaret)	9690	9399	291	9706	306	3%	25%
419	Johansen W. of College (2)	21940	20404	1536	18703	-1701	-8%	15%
1871	Phillips (W. of Driveway St.)	4495	4225	270	4145	-80	-2%	50%
103	First Ave (Barnette – Cushman)	9230	8676	554	10400	1724	19%	25%
358	Airport Way (Cushman)	18510	17955	555	17563	-392	-2%	15%
1135	FARMERS LOOP RD	5370	5048	322	4890	-158	-3%	25%
450	STEESE HWY	4700	4324	376	4236	-88	-2%	50%
	Total	**73935**	**70032**	**4659**	**69644**	**-387**	**-1%**	

North – South Screenline (Far East Side Fairbanks)

Link ID	*Link Description from Model*	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
477	RICHARDSON HWY	21115	19004	2112	18247	-757	-4%	20%
524	BADGER RD	6727	6391	336	7530	1140	17%	50%
1995	CHENA HOT SPRINGS RD	5230	4969	262	5308	339	6%	50%
	Total	**33072**	**30363**	**1170**	**31085**	**722**	**2%**	

East - West Screenline (Chena River)

	Link Description from Model	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
396	Parks HW South of interchange	14750	13718	1033	15950	2232	15%	20%
1403	University (S. of Johansen (2))	17840	16770	1070	15113	-1656	-9%	20%
616	Peger (Phillips – Alaskaland)	14875	13834	1041	13912	78	1%	20%
349	Cushman (River – Terminal)	13590	12911	680	13241	330	2%	20%
692	Wendell St. Bridge	8985	8356	629	8857	501	6%	25%
427	Steese Expy (3rd St.)*	23990	22551	1439	25403	2852	12%	15%
677	CHENA PUMP RD	7842	7293	549	7219	-74	-1%	20%
2203	CHENA RIDGE RD	4145	3855	290	3136	-719	-17%	100%
1304	GEORGE PARKS HWY	5765	5016	749	3990	-1026	-18%	50%
	Total	**111782**	**104301**	**7377**	**106821**	**2519**	**2%**	

East – West Screenline (South of Airport Way)

	Link Description from Model	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
1407	University (Davis Rd)	8975	7808	1167	6618	-1191	-13%	25%
617	Peger (S of Airport)	9285	8635	650	9094	459	5%	25%
644	W Cowles (19th Ave.-E. Cowles)	6730	6528	202	4941	-1587	-24%	25%
642	Cushman (17 Ave. - 15th Ave)	9595	9307	288	8865	-442	-5%	20%
435	Rich Hwy (Parks EB)	19240	17893	1347	20217	2324	12%	20%
605	AIRPORT WAY	7500	7050	450	5276	-1774	-24%	50%
677	CHENA PUMP RD	7842	7293	549	7219	-74	-1%	50%
524	BADGER RD	6727	6391	336	7530	1140	17%	50%
	Total	**75894**	**70905**	**4848**	**69761**	**-1145**	**-2%**	

East – West Screenline (North of Johansen)

	Link Description from Model	*2009 Ground Count*	*Passenger Count*	*Truck Count*	*Passenger Model*	*Error**	*%Error*	*FHWA Target*
2269	SHEEP CREEK RD	2410	2217	193	2159	-58	-2%	100%
2300	BALLAINE RD	2790	2678	112	3284	605	22%	100%
1326	SUMMIT DR	1710	1607	103	1726	119	7%	100%
905	SKYLINE DR	1457	1355	102	1647	292	20%	100%
903	MCGRATH RD	1340	1260	80	1102	-158	-12%	100%
883	OLD STEESE HWY	3755	3530	225	2862	-668	-18%	50%
1996	STEELE CREEK RD	955	898	57	1142	244	26%	200%
864	NORDALE RD	1845	1716	129	1183	-533	-29%	100%
1992	GILMORE TRL	1315	1236	79	769	-467	-35%	100%
893	OLD STEESE HWY	985	926	59	532	-394	-40%	200%
	Total	**18562**	**17423**	**1287**	**16406**	**-1017**	**-5%**	

*Passenger counts are the AADT of the road minus the truck counts. If the truck traffic percentage is not available for a particular road, estimation of the percentage is based on the closest road that has the truck data. Roads that mainly serve residential areas are assumed to have no truck traffic.
** Difference = model number - count
***Model Validation and Reasonableness Checking Manual, Travel Model Improvement Program, FHWA, February 1997

Driving Speed Calibration

For the purpose of mobile source $PM_{2.5}$ emission modeling, the accuracy of driving speed estimation on the roads in the non-attainment area is important. To achieve a better accuracy than what the typical TDF model can offer, GPS-based floating car runs were used to collect average driving speed data on corridors that have high traffic volumes for calibration of a link driving speed model. Note that the driving speed calibration was done in 2010 for FMATS' LRTP 2035 conformity analysis. The same calibrated driving speed model is used for this model update.

Volume-induced delay in the FMATS area occurs almost exclusively at the intersections. Within a certain distance adjacent to the intersections, vehicles have to slow down to and speed up from the intersections. To properly model driving speed on the roads, it is necessary to separate the sections of the roads where delay due to traffic signals at the intersections.

The driving speed model contains two steps. The first step models the driving speed at the mid section of a roadway link. The mid-sections are at a certain distance from an intersection where the vehicles have accelerated to the average speed of the traffic flow. The second step models the distance and average speed from the intersections where acceleration and deceleration of the vehicles take place.

Mid-Section Driving Speed

The link performance function of the Bureau of Public Roads (BPR) is used as the model for driving speed on a road. The formulation of the BPR function is:

$$t_v = t_0 \, (1 + \alpha (\frac{V}{C})^{\beta})$$

t_v = time required to drive through a road when there is traffic on the road
t_0 = time required to drive through a road when there is little to no traffic on the road (i.e., free flow time)
V = Peak hour traffic volume on the road
C = hourly capacity of the road
α = parameter to be calibrated from data
β = parameter to be calibrated from data

The GPS speed data are used to calculate the driving time t_v on the roads. The free flow time t_0 of a road is calculated with the driving speed at the speed limit of the road. The PM peak hour volumes V on major roadways are obtained from AK DOT & PF. The capacity C of a road is based on the functional classification of the road.

A total number of 22 two-way road segments (i.e., 44 uni-directional links) with peak hour volume and speed data is used for the speed model calibration. The model is calibrated using the PM peak hour data (i.e., more volume and speed data are available for the PM peak hour). The calibration process is essentially to find a set of α and β values such that the BPR function with observed volume and speed data produces the smallest average error (i.e., root mean square error) of all the calibration links.

The result of the driving speed model calibration is shown in Figure 7. The number on the highlighted calibration links is the model error in miles per hour mph). The result appears to be satisfactory, since the largest error is less than 4 mph and most of the links are within an error of 2 mph.

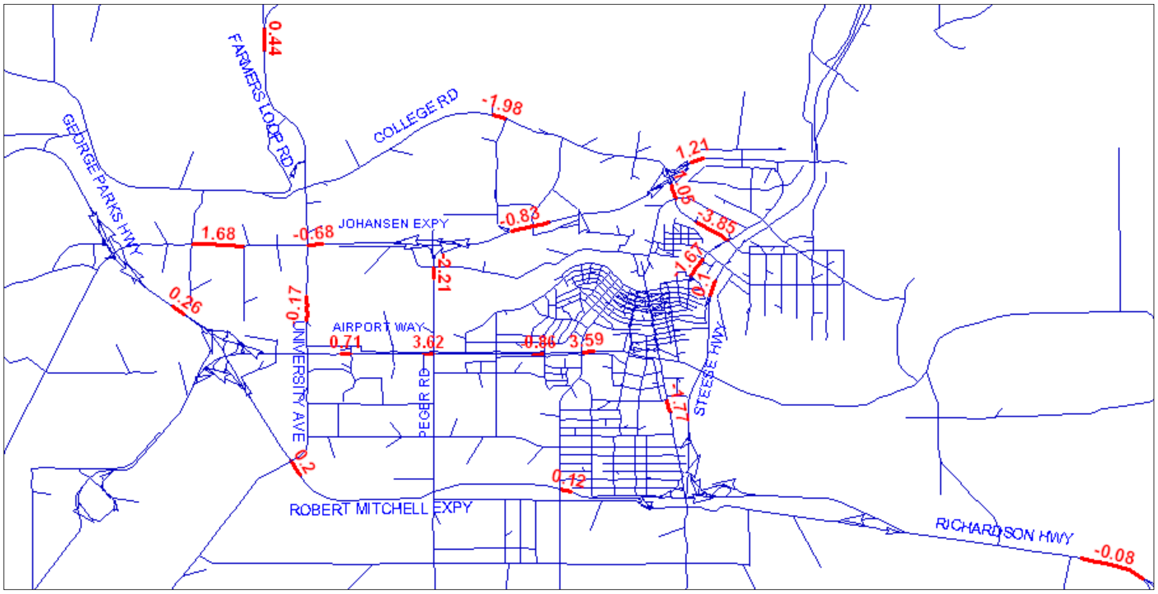

Figure 7 Results of the Speed Model Calibration

The off-peak hour driving speed for a road cannot be reasonably modeled with the BPR function because during many of the late night hours there is essentially no traffic on the roads (i.e., the v/c ration is 0). The driving speed on a road during the off-peak hour is assumed to be at the speed limit of the road. The assumption is based on the observation that some drivers tend to drive over the speed limits during the off-peak hours.

Acceleration and Deceleration Segments

On the segment of a road where acceleration from the signal takes place, the average driving speed of a vehicle is taken as the average of the initial speed at the beginning of the segment and the final speed at the end of the segment when a vehicle reach the mid-section speed. With the collected GPS speed data, the average driving speed on the segments that are connected to a signal is estimated to be approximately 3/4 of the average mid-section driving speed. Figure 8 shows an example of the results of the driving speed modeling on the acceleration and deceleration segments. The highlighted links are the acceleration and deceleration segments. The length of the segment reflects the acceleration rate and the mid-section speeds of the links.

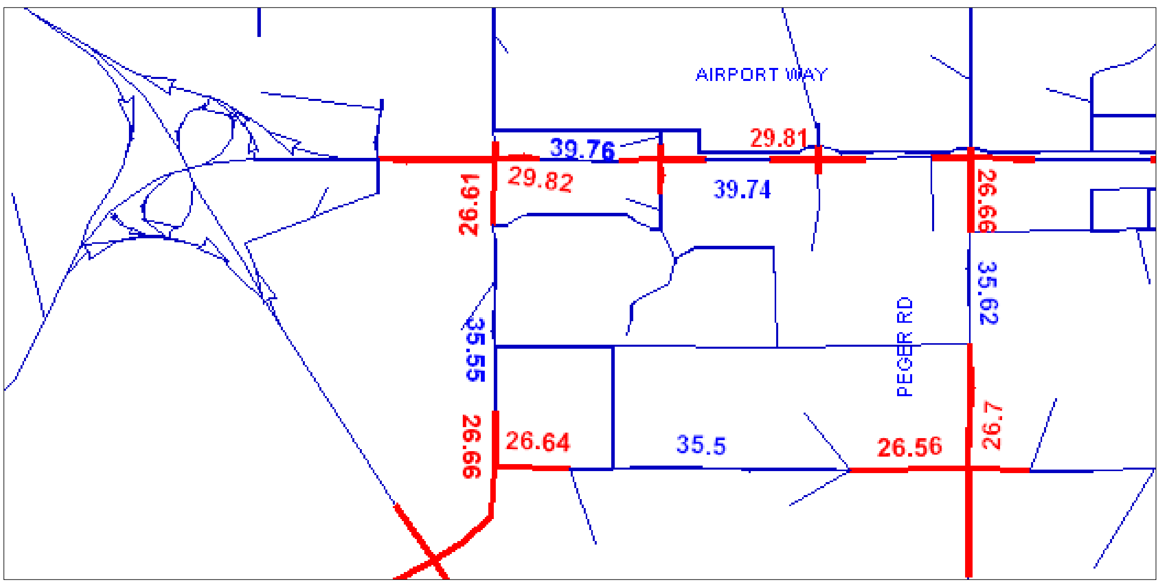

Figure 8 The Lengths and Average Speed on Segments Adjacent to Traffic Signals

MEMORANDUM

TO: FAIRBANKS METROPOLITAN AREA TREANSPORTATION SYSTEMS

FROM: MING S. LEE

SUBJECT: FMATS 2035 TRAFFIC PROJECTION REPORT

DATE: 06/30/2011

CC:

Attached with this memo is the report for the 2035 traffic projected with the basis of the new 2010 Census data.

Please let me know if you have any questions, comments and suggestions for the model work. I appreciate the opportunity of working on the model for FMATS.

FMATS 2035 Traffic Forecast with Projection Basis of 2010 Census

June 30, 2011

Prepared by

Ming S. Lee, Ph.D.

for

The Fairbanks Metropolitan Area Transportation Systems

INTRODUCTION

This report highlights the three major components involved in projecting 2035 traffic condition in the FMATS model area: Household projection, employment projection, and the 2035 model network modification for the $PM_{2.5}$ non-attainment area. The projection is made on the basis of 2010 Census data.

2035 NUMBER OF HOUSEHOLD PROJECTION

The model requires 2035 projection of households by vehicle ownership and number of persons. Based on the most recent 2010 Census data, the Fairbanks North Star Borough (FNSB) performed the 2035 household projection for all the Census Block Groups (BG) in the FMATS model area. A growth rate is projected for each BG and the percentages of the growth within each BG attributing to different vehicle ownership and household size categories are also projected. Table 1 presented the growth rates projected by FNSB.

To apply the BG growth rates to TAZs, the BG that a TAZ belongs to is first identified. The growth rate of that BG is then applied to the baseline number of households (i.e., occupied units) of the TAZ to project the numbers of number of households in 2035.

Because the 2010 Census Redistricting data released in March 2011 do not contain auto ownership and household size data, there is no information to update the 2035 projection by these two subgroups. The proportions of households by ownership and household size groups from the previous projection for FMATS' 2035 LRTP are thus retained. The projected total household number for each TAZ is multiplied with the proportions to arrive at the numbers of households by auto ownership and household size groups in 2035.

Table 1 Household Growth Rates Projected by FNSB

CENSUS BLOCK GROUP/TRACT	Unique Census BG ID#	Geographic Description	Total HH (Census 2010)*	% HH Projected Growth (2010-2035)
BG 1, Tract 1	**1**	Townsite / Cushman / Steese	**767**	1.027%
BG 2, Tract 1	**41**	Townsite	**443**	1.208%
BG 1, Tract 2	**88**	Townsite / Cowles / Lathrop	**921**	0.483%
BG 2, Tract 2	**142**	Van Horn Industrial (City) / Townsite Weeks Field	**558**	0.665%
BG 1, Tract 3	**178**	Bjerremark / Rickert	**354**	1.390%
BG 2, Tract 3	**198**	Bjerremark	**649**	1.329%
BG 3, Tract 3	**240**	South Cushman	**663**	0.967%
BG 4, Tract 3	**266**	Bjerremark / South Cushman	**453**	1.208%
BG 1, Tract 4	**312**	Shannon Park	**546**	2.236%
BG 2, Tract 4	**331**	Hamilton Acres / North West	**273**	0.665%
BG 3, Tract 4	**348**	Hamilton Acres East	**394**	0.483%
BG 4, Tract 4	**377**	Hamilton Acres / Chena North	**712**	0.604%
BG 1, Tract 5	**403**	Aurora - Lemeta	**765**	0.604%
BG 2, Tract 5	**428**	Doyon Estates / Alaska Railroad / Townsite Weeks Field	**721**	1.450%
BG 1, Tract 6	**501**	Aurora - Lemeta	**496**	0.483%
BG 2, Tract 6	**519**	College Road / Aurora - Lemeta	**575**	2.054%
BG 3, Tract 6	**561**	College Road / Totem Park	**285**	1.631%
BG 4, Tract 6	**581**	College Road West	**429**	1.873%
BG 1, Tract 7	**595**	Taku-Westgate / Airport Road	**757**	0.665%
BG 2, Tract 7	**641**	Sophie Plaza / Market Street	**597**	0.242%
BG 3, Tract 7	**647**	Davis / Van Horn	**550**	2.356%
BG 1, Tract 8	**672**	Geist Road	**548**	1.148%
BG 2, Tract 8	**706**	University West / Geist Road	**934**	1.450%
BG 3, Tract 8	**728**	Dartmouth Drive	**343**	0.725%
BG 4, Tract 8	**744**	University West	**381**	1.148%
BG 1, Tract 9	**760**	Chena Ridge	**1,317**	2.054%
BG 2, Tract 9	**809**	Rosie Creek	**1,291**	2.356%
BG 1, Tract 10	**845**	Smith Broadmoor / International Airport	**344**	1.813%
BG 2, Tract 10	**910**	Davis Van Horn / Van Horn Industrial (City)	**342**	1.329%
BG 1, Tract 11	**1028**	Ft. Wainwright AFB	**2,113**	1.631%
BG 1, Tract 12	**1069**	Chena Hot Springs Hills	**1,468**	2.719%
BG 2, Tract 12	**1202**	Farmers Loop / McGrath Road / Steese Highway	**446**	1.934%
BG 3, Tract 12	**1247**	Farmers Loop / Skyline Drive / McGrath Road	**846**	2.356%

BG 1, Tract 13	**1271**	College Road / Farmers Loop / Creamers Field	**619**	1.148%
BG 2, Tract 13	**1321**	Farmers Loop North	**456**	2.538%
BG 3, Tract 13	**1338**	Farmers Loop West	**810**	1.692%
BG 4, Tract 13	**1367**	Ballaine Road / Sheep Creek Road	**403**	1.934%
BG 5, Tract 13	**1386**	UAF	**213**	0.544%
BG 1, Tract 14	**1405**	Persinger Drive / Nordale	**564**	2.779%
BG 2, Tract 14	**1446**	Lakloey - Persinger	**516**	2.840%
BG 3, Tract 14	**1476**	Bradway /Aztec Road / Lakloey	**503**	2.719%
BG 4, Tract 14	**1498**	Bradway - Clear Creek	**322**	1.752%
BG 5, Tract 14	**1522**	Bradway	**1,074**	2.175%
BG 1, Tract 15	**1606**	Peede Road / Chena River	**603**	2.054%
BG 2, Tract 15	**1649**	Badger East / Repp Road / Plack Road	**580**	2.538%
BG 3, Tract 15	**1685**	Badger East / Plack Road / Hurst Road	**565**	2.779%
BG 4, Tract 15	**1716**	Dawson Road / Nelson Road	**800**	1.450%
BG 5, Tract 15	**1781**	Chena Lakes Flood Control	**854**	1.329%
BG 6, Tract 15^	**1828**	Moose Creek	**332**	1.571%
BG 1, Tract 16	**1868**	Badger East	**364**	2.417%
BG 2, Tract 16	**1906**	North Pole City	**559**	2.840%
BG 3, Tract 16	**1955**	North Pole City East	**681**	2.840%
BG 4, Tract 16	**2037**	Laurance Road / Dyke Road	**421**	1.934%
BG 1, Tract 17	**2084**	Eielson Farm Road	**614**	1.390%
BG 2, Tract 17^	**2169**	Harding Lake	**723**	1.148%
BG 1, Tract 18^	**2214**	Eielson Training Area	**0**	0.302%
BG 2, Tract 18^	**2216**	Eielson AFB	**892**	0.665%
BG 1, Tract 19^	**2233**	Chena Hot Springs Rd	**828**	2.115%
BG 2, Tract 19	**2291**	Two Rivers	**1,471**	2.659%
BG 3, Tract 19^	**2352**	Elliott Hwy/Steese Hwy	**643**	1.752%
BG 4, Tract 19^	**2435**	Parks Hwy/NW Borough	**2,327**	2.236%
BG 5, Tract 19	**2563**	Gold Hill	**765**	1.571%
FNSB ALL TOTAL	**-**	-	**41,783**	**100%**

* These numbers include both occupied and vacant housing units

2035 NUMBER OF EMPLOYMENT PROJECTION

Projection Models

2001 to 2010 industry employment estimation for the FNSB produced by the Research and Analysis Section of Alaska Department of Labor (DOL) and Workforce Development is used to develop the 2035 employment projection for FNSB.

The annual employment growth rate of 1% is used to project the number of employment in 2035. The 1% annual growth rate projection is made by the Institute of Social Economic Research of the University of Alaska Anchorage[107]. Table 2 shows the 2001-2010 data from DOL data and the annual projections made with a 1% annual growth rate. It shows that over the last 10 years employment in FNSB grew in an approximate 1% annual growth rate. Thus, the 1% annual growth rate is applied to the 2010 number of employment in each TAZ to make employment projection for 2035.

Table 2 FNSB Industry Employment Estimates 2001-2010

Industry	**2,001**	**2,002**	**2,003**	**2,004**	**2,005**	**2,006**	**2,007**	**2,008**	**2,009**	**2,010**
Natural Resources & Mining	950	900	900	900	1,000	1,000	1,000	1,100	1,100	1,100
Construction	2,000	2,250	2,500	2,800	2,900	2,800	2,800	2,700	2,500	2,700
Manufacturing	550	500	500	600	600	600	700	600	700	600
Wholesale Trade	500	550	600	600	600	700	700	700	700	700
Retail Trade	3,900	4,100	4,000	4,400	4,700	4,700	4,700	4,700	4,600	4,500
Trans/Warehouse/Utilities	2,600	2,650	2,500	2,400	2,300	2,400	2,400	2,400	2,500	2,500
Information	600	600	600	600	600	600	600	600	500	500
Financial Activities	1,300	1,300	1,400	1,400	1,500	1,600	1,600	1,500	1,600	1,500
Professional & Business Svcs	2,100	1,850	2,100	2,200	2,200	2,200	2,300	2,300	2,200	2,300
Educational & Health Services	3,400	3,800	4,000	4,100	4,200	4,300	4,200	4,400	4,600	4,900
Leisure & Hospitality	3,700	3,850	4,000	4,200	4,100	4,100	4,300	4,200	4,000	4,100
Other Services	1,950	1,800	1,400	1,400	1,300	1,300	1,300	1,200	1,200	1,200
Government	11,150	11,350	11,500	11,600	11,700	11,700	11,900	12,000	12,000	12,300
Grand Total	**34,700**	**35,500**	**36,000**	**37,200**	**37,700**	**38,000**	**38,500**	**38,400**	**38,200**	**38,900**
Projected with 1% annual growth		**35,047**	**35,855**	**36,360**	**37,572**	**38,077**	**38,380**	**38,885**	**38,784**	**38,582**

107 Economic and Demographic Projections for Alaska and Greater Anchorage 2010–2035, Scott Goldsmith. Prepared for HDR Alaska, Inc. in association with Northern Economics December 2009.

http://www.iser.uaa.alaska.edu/Publications/EconDemProjectionsAnchorage_v4.pdf

2035 Trip Production and Attraction Projection

Once the household and employment projection are performed for all the TAZs, the same trip production and attraction models used in the baseline model are applied with the 2035 household and employment data to produce the projection of 2035 TAZ trip production and attraction.

2035 Trip Tables forecasts

The calibrated baseline friction factor table and the hourly departure and return rate table are applied to the 2035 trip production and attraction to produce the 2035 time period vehicle trip table: AM peak for 7 to 9 am, PM peak for 3 to 5 pm, and off-peak for the remaining hours.

The vehicle occupancy factors used for different trip purposes are the same as those for the baseline model:

- 1.11 persons per vehicle for HBW
- 1.67 persons per vehicle for HBNW
- 1.66 persons per vehicle for NHB.

Finally, each of these vehicle trip tables are added with the 2035 external-to-external vehicle trip table (i.e., projected with the same annual growth rate as employment) of the same period to form complete period vehicle trip table for 2035 traffic assignment.

2035 Truck Traffic Projection

The 2010 base line truck O-D matrix is multiplied with the total of 1.28 growth rate (i.e., 1% annual growth over 25 years) for the projection of 2035 truck O-D matrix. The forecasted truck traffic is the result of assignment of the 2035 truck O-D matrix to the 2035 roadway network

2035 LRTP TRANSPORTATION NETWORK

The planning network representing the 2035 modeling scenario is prepared by incorporating the recommended roadway projects listed in the 2035 FMATS LRTP, the 2012-2015 Transportation Improvement Program (TIP), and the future project list in the donut area identified by FMATS.

Generally, projects involving bike and pedestrian facilities are not represented in the model network, which is mainly used for projection of vehicular traffic. The model network also does not recognize projects intended for safety and intersection improvements, because such improvements typically do not induce major travel behavior change like roadway upgrading that will increase the travel speed and capacity. Pavement rehabilitation is also not modeled. There are also projects that involved particular streets that are not presented in the model. The reasons that the streets are not in the model network are due to low functional classification of due to the fact that they are not a link that connect major traffic generators.

Table 3 shows the list of projects planned for the 2012-2015 TIP. A description of the planned projects in the donut area is included in the Appendix.

Table 3 FMATS 2012-2015 TIP Projects

FMATS 2012 - 2015 TRANSPORTATION IMPROVEMENT PROGRAM - DRAFT

NID	AKSAS	Score	Project Description	Fund Code	Sponsor	Phase	FFY11	FFY12	FFY13	FFY14	FFY15	Beyond
FCTP=FMATS CTP & TRAAK GCTP= FMATS Grandfathering GTI=Governors Transportation Intiative GF=General Fund CMAQ=Congestion Mitigation Air Quality 1702=SAFETEA-LU Earmark High Priority 1306=SAFETEA-LU Earmark Freight Intermodal 3044=SAFETEA-LU Earmark Bus related 115=2005 Section 115 Earmark 3037=FTA JARC 381=HB 381 Tobacco bill Y381=HB 381 Yankovich/Miller Path FEDCTP=Fed share only CTP & TRAAK M381=HB 381 used as match NCPBD= National Corridors and Border Development UNF=Unfunded DEOB=FMATS project deobligations PL = FHWA Planning Funds-Fed Share Only EPA = Environmental Protection Agency NP = City of North Pole STIP-PM STIP Preventive Maintenance STIM-GHU Golden Heart Utilities ARRA ILLU=Illustrative AC=Advance Construct ACC=Advance Construct Convert S-STP Sign Replacement STP UAF = University of Alaska SB230 = Senate Bill 230 Funding College - SB230 for College Road												
CTP - Projects												
9946		57.7	**Bradway Rd Reconstruction: FNSB**	FCTP	FMATS	2						799.0
			Reconstruct Bradway Road (in the North Pole area) between Dennis Road and Badger Elementary School.	FCTP		3						61.0
				FCTP		7						
				FCTP		4						17,812.0
			Project Total									18,672.0
13699	62164	99	**College Road Rehab (Univ. to Danby) & Intersection: Fairbanks**	FCTP	FMATS	2						
			Rehabilitate and repave College Road between University Avenue and Danby Street. Including intersection improvements along the route.	College		3	300.0					
				College		7	150.0					
			College = SB230 $4.5M	College		4		4,050.0				
				FCTP		4		4,720.0				
			Project Total				450.0	8,770.0				
19103		99	**Cowles Street Reconstruction: Fairbanks**	FCTP	FMATS	2						1,667.0
			Reconstruct Cowles Street from 1st Avenue to 10th Avenue.	FCTP		3						195.0
				FCTP		7						3,650.0
				FCTP		4						6,899.0
			Project Total									12,411.0

RESULTS OF 2035 FORECASTING

The forecasted 2035 trip tables of the three time periods are assigned to the 2035 model network. The assignment produces 2035 traffic forecasts representing 2035 traffic conditions. Table 4 shows the comparison of model total VMTs of the 2035 and 2010 baseline.

Table 4 Comparison of Total Model VMT

Scenario	**Total** $PM_{2.5}$ **Non-attainment area VMT**	**Total CO Non-attainment VMT**
2010 Baseline Model	1,823,895	918,868
2035 Model	2,388,715	1,160,946

The mid-section driving speed model calibrated for the 2010 baseline model is applied with the 2035 forecasted traffic volume. The lengths of the acceleration and deceleration segments are then calculated based on the mid-section speeds.

Appendix: Planned Projects in the Donut Area

Table 5 shows the planned projects in the Donut area from all funding sources. Those shown as short range, medium range or long range projects are included in the year 2035 model network and associated cost. Historically, projects in the Donut area have received between 6 and 8 million dollars yearly.

Table 5Short, Medium and Long Range Donut Area Projects

SR - 1	Elliott Highway MP 0 – 12 Rehabilitation
SR - 2	Nordale Road (Chena River – Chena Hot Springs Road)
SR - 3	Old Steese Rehabilitation (Hagelbarger to New Steese)
SR - 4	Steele Creek Road Surfacing (Chena Hot Springs Road to Gilmore Trail)
SR - 5	FNSB: Park and Ride
SR - 6	Pavement Management / Preventive Maintenance
SR - 7	Gold Mine Trail Road
SR - 8	Rosie Creek Road
SR - 9	Old Nenana / Ester Hill Rehabilitation
MR - 1	Chena Hot Springs Road (MP 0 – 6)
MR - 2	Farmer’s Loop Road (MP 0 – 8.433)
MR - 3	Goldstream Road (Old Steese to Murphy Dome Road)
MR - 4	Old Steese (Johansen to McGrath)
MR - 5	Plack Road Bike Path
MR - 6	McGrath Road Upgrade
MR - 7	Park’s Highway (MP 305 – 351)
MR - 8	Grenac Road Resurfacing
MR - 9	Pavement Management / Preventive Maintenance
LR - 1	Chena Pump Road (MP 0 – 4.6)
LR - 2	Chena Ridge Road (MP 0 – 8.111)
LR - 3	Sheep Creek Road (Black Sheep Lane to Goldstream Road)
LR - 4	Bennett Road Resurfacing (MP 0 – 1.48)
LR - 5	Nelson Road
LR - 6	Farmer’s Loop – Chena Hot Springs Trail
LR - 7	Goldstream Valley Multi-use Trail
LR - 8	Murphy Dome Road Rehabilitation
LR - 9	Plack Road Upgrade and Dawson Road Connector
LR - 10	Spinach Creek Road Rehabilitation
LR - 11	Pavement Management / Preventive Maintenance

Following is a brief description of each of the recommended Short-Range, Medium-Range, and Long-Range projects and how the projects are incorporated into the spending plan. Fairbanks has recently benefited from additional funding including stimulus funding which has increased spending within the short range projects. This trend currently is not expected to continue in the future.

Recommended Short-Range Projects (2010 – 2015)

SR-1 ***(NHS) Elliott Highway: MP 0 – 12 Rehabilitation*** – Rehabilitate the Elliott Highway between MP 0 – 12. (Note: 0.5 miles within Donut area.)
SR-2 ***(CTP) Nordale Road:*** Rehabilitate and resurface Nordale Road from Chena River (MP 2.367) to Chena Hot Springs Road (MP 5.663). (Note: 0.4 miles within Donut area)
SR-3 ***(CTP) Old Steese: Hagelbarger – New Steese:*** Rehabilitate the Old Steese from Hagelbarger to the New Steese Highway. (Note: Project is approximately 4.4 miles and all within the Donut area.)
SR-4 ***(CTP) Steele Creek Road:*** Surface Steele Creek Road between Chena Hot Springs Road (MP 0.0) to Gilmore Trail (MP 3.0). (Note: Project is approximately 3 miles and all within the Donut area.)

SR-5 ***(FTA-CMAQ) FNSB: Park and Ride:*** Provide parking lots for commuters to access the Metropolitan Area Commuter System (MACS) bus service. Locations identified are North Pole, Chena Hot Springs Road, Goldstream Road, Richardson Highway, Fox and Ester. (Note: Estimated 10% of project cost to be within the Donut area.)
SR-6 ***(STP) Pavement Management / Preventive Maintenance:*** Preventive Maintenance projects throughout Donut area. (Note: Estimated Preventive Maintenance funding within the Donut area is $500,000 yearly.)
SR-7 ***(STP) Gold Mine Trail Road:*** Upgrade, realign and pave 4,750 feet of Gold Mine Trail and replace guardrail. Consider relocation of the Goldmine Trail / Steese Highway intersection. (Note: Project is approximately 0.9 miles and all within the Donut area.)
SR-8 (***STP) Rosie Creek Road:*** Upgrade Rosie Creek Road from Chena Ridge to Becker Ridge, to include alignment, shoulder work, repair and overlay of pavement and improving the intersection at Chena Ridge. (Note: Project is approximately 2.4 miles all within the Donut area.)
SR-9 (STP) ***FNSB: Old Nenana / Ester Hill Rehabilitation***: Resurface and improve the road grade4s, widen the road, and install guardrail along the Old Nenana Highway.

PROJECT	DESCRIPTION	TOTAL ESTIMATED COST	COST WITHIN DONUT AREA
SR - 1	Elliott Highway MP 0 – 12 Rehabilitation	$26,500,000	$1,325,000
SR - 2	Nordale Road	$2,925,000	$468,000
SR - 3	Old Steese Rehabilitation	$13,200,000	$13,000,000
SR - 4	Steele Creek Road Surfacing	$3,000,000	$3,000,000
SR - 5	FNSB: Park and Ride	$725,000	$72,500
SR - 6	Pavement Management / Preventive Maintenance	$2,500,000	$2,500,000
SR - 7	Gold Mine Trail	$2,500,000	$2,500,000
SR - 8	Rosie Creek Road	$7,400,000	$7,400,000
SR – 9	FNSB: Old Nenana / Ester Hill Rehabilitation	$12,600,000	$12,600,000
	5 year total	**$71,350,000**	**$42,865,500**
	1 year average	**$14,270,000**	**$8,573,100**

<u>Recommended Med-Range Projects (2016 – 2025)</u>
MR-1 ***(AHS) Chena Hot Springs Road*** – Rehabilitate Chena Hot Springs Road from MP 0 – 6. (Note: Project is approximately 6 miles with 1.7 miles within Donut area.)
MR-2 ***(CTP) Farmer's Loop:*** Relevel and resurface Farmers Loop Road MP 0 – 8.43. (Note: Project is approximately 8.43 miles with 3.6 within Donut area)
MR-3 ***(CTP) Goldstream Road Reconstruction or Rehabilitation:*** Rehabilitate Goldstream Road from the Old Steese Highway to Murphy dome Road. Relevel and pave with spot repairs in more critical areas. (Note: Project is approximately 10.2 miles and all within the Donut area.)
MR-4 ***(CTP) Old Steese: Johansen to McGrath Road:*** Construct new roadway from the Old Steese intersection with the Johansen to McGrath Road. (Note: Project is approximately 2 miles with 1.6 miles within Donut area.)
MR-5 ***(TRAAK) Plack Road Bike Path:*** Construct a separated bike path along Plack Road from Nelson to Badger. (Note: Project is approximately 3.21 miles with .5 miles within the Donut area.)
MR-6 ***(CTP) McGrath Road Upgrade:*** Upgrade lower McGrath Road from Crystal Drive – Farmers Loop. (Note: Project is approximately 1.28 miles with .25 miles within the Donut area.)
MR-7 ***(NHS) Parks Highway MP 305-351: Fairbanks – Nenana Scenic Waysides:*** Upgrade existing waysides / overlooks along the Parks Highway Nenana Ridge MP 305 – 351. (Note: Project is approximately 46 miles with 1.3 miles within the Donut Area.)
MR-8 ***(CTP) Grenac Road Resurfacing:*** Major Rehabilitation and repaving of Grenac Road. (Note: Project is approximately 1.15 miles with .25 within the Donut area.)
MR-9 ***(STP) Pavement Management / Preventive Maintenance:*** Preventive Maintenance projects throughout Donut area. (Note: Estimated Preventive Maintenance funding within the Donut area is $500,000 yearly.)

PROJECT	DESCRIPTION	TOTAL ESTIMATED COST	COST WITHIN DONUT AREA
MR - 1	Chena Hot Springs Road	$6,400,000	$3,456,000
MR - 2	Farmer's Loop	$8,640,000	$3,628,800

MR - 3	Goldstream Road	$15,000,000	$15,000,000
MR - 4	Old Steese: Johansen to McGrath	$13,200,000	$9,900,000
MR - 5	Plack Road Bike Path	$3,000,000	$500,100
MR - 6	McGrath Road	$2,930,000	$586,000
MR - 7	Parks Highway	$3,500,000	$105,000
MR - 8	Grenac Road Resurfacing	$1,200,000	$264,000
MR - 9	Pavement Management / Preventive Maintenance	$5,000,000	$5,000,000
	10 year total	**$58,870,000**	**$38,439,100**
	1 year average	**$5,887,000**	**$3,833,910**

Recommended Long-Range Projects (2026 – 2035)

LR-1 ***(CTP) Chena Pump Road*** – Rehabilitate Chena Pump Road from MP 0 – 4.6. (Note: Project is approximately 4.6 miles with 2.6 miles within Donut area.)

LR-2 ***(CTP) Chena Ridge Road:*** Rehabilitate Chena Ridge Road from MP 0 – 8.11. (Note: Project is approximately 8.11 miles and all within Donut area)

LR-3 ***(CTP) Sheep Creek Road Rehabilitation:*** Rehabilitate and resurface Sheep Creek Road from Blacksheep Lane (MP 2.669) to Goldstream Road (MP 5.260). (Note: Project is approximately 2.6 miles and all within the Donut area.)

LR-4 ***(CTP) Bennett Road Resurfacing:*** Rehabilitate and repave Bennett Road from MP 0 – 1.48. (Note: Project is approximately 1.48 miles and all within the Donut area.)

LR-5 ***(CTP) Nelson Road Rehabilitation:*** Rehabilitate and resurface Nelson Road from MP 0 – 3.00. (Note: Project is approximately 3 miles with 1.0 mile within the Donut area.)

LR-6 ***(TRAAK) Farmer's Loop to Chena Hot Springs Road Trail:*** Acquire easements for and plat the historic winter trail between Fairbanks and Chena Hot Springs Road. (Note: Project is approximately 59.3 miles with 3.25 miles within the Donut area.)

LR-7 ***(TRAAK) Goldstream Valley Multi-Use Trail:*** Extend multi-use trail between Sheep Creek Road / Ann's Greenhouse (MP 3.41) to Goldstream / Ballaine Road (MP7.79). (Note: Project is approximately 4.55 miles and all within the Donut area.)

LR-8 ***(CTP) Murphy Dome Road Rehabilitation:*** Repave Murphy Dome Road from Goldstream Road MP 0 to MP 8.60. (Note: Project is approximately 8.6 miles with 2.75 within the Donut area.)

LR-9 ***(CTP) Plack Road Upgrade and Dawson Connector:*** Upgrade existing roadway and extend to Dawson Road. (Note: Project is approximately 3.7 miles with 1 mile within the Donut area.)

LR-10 ***(CTP) Spinach Creek Road Rehabilitation:*** Rehabilitate and repave Spinach Creek Road from Murphy Dome Road to Old Murphy Dome Road. (Note: Project is approximately 4.36 miles all within the Donut area.)

LR-11 ***(STP) Pavement Management / Preventive Maintenance:*** Preventive Maintenance projects throughout Donut area. (Note: Estimated Preventive Maintenance funding within the Donut area is $500,000 yearly.)

PROJECT	DESCRIPTION	TOTAL ESTIMATED COST	COST WITHIN DONUT AREA
LR - 1	Chena Pump Road	$4,600,000	$2,800,000
LR - 2	Chena Ridge Road	$8,100,000	$8,100,000
LR - 3	Sheep Creek Road	$2,600,000	$2,600,000
LR - 4	Bennett Road	$610,000	$610,000
LR - 5	Nelson Road	$2,500,000	$1,650,000
LR - 6	Farmer's Loop – Chena Hot Springs Trail	$5,700,000	$342,000
LR - 7	Goldstream Valley Multi-use Trail	$2,000,000	$2,000,000
LR - 8	Murphy Dome Road Rehabilitation	$8,300,000	$2,656,000
LR - 9	Plack Road Upgrade and Dawson Connector	$5,750,000	$1,380,000
LR - 10	Spinach Creek Road Rehabilitation	$3,000,000	$3,000,000
LR - 11	Pavement Management / Preventive Maintenance	$5,000,000	$5,000,000
	10 year total	**$48,160,000**	**$30,138,000**
	1 year average	**$4,816,000**	**$3,013,800**

Attachment C

Vehicle Fleet Inputs Documentation

Alaska DMV Database – Class Code Scheme

Class Code	Description	IM Required	On-Road Vehicle
10	Passenger Personalized	T	T
11	Passenger	T	T
14	For Hire (Taxicab)	T	T
15	Historical Vehicle	F	T
16	Call Letter Passenger	T	T
17	Dealer Plate (1st Set)	T	T
19	Dealer Plate (2nd & Subsequent Sets)	T	T
20	Motorcycle Personalized	F	T
21	Motorcycle	F	T
25	Historic Vehicle - Exhibition	F	T
28	Dealer Motorcycle (1st Set)	F	T
29	Dealer Motorcycle (2nd Set)	F	T
31	Commercial Trailer: 5,000 lbs. and Under	F	F
32	Commercial Trailer: 5,001 lbs. - 12,000 lbs.	F	F
33	Commercial Trailer: 12,001 - 18,000 lbs.	F	F
34	Commercial Trailer: Over 18,000 lbs.	F	F
35	Non-Commercial Trailer	F	F
38	Transporter (1st Set)	F	T
39	Transporter (2nd & Subsequent Sets)	F	T
40	Non-Commercial Pickup Personalized	T	T
41	Commercial Truck: 5,000 lbs. & Under	T	T
42	Commercial Truck: 5,000 lbs. - 12,000 lbs.	T	T
43	Commercial Truck: 12,001 lbs. - 18,000 lbs.	F	T
44	Commercial Truck: Over 18,000 lbs.	F	T
45	Non-Commercial Pickup and Van	T	T
46	Call Letter Pickup (No Equipment)	T	T
51	Bus: 5,000 lbs. & Under	F	T
52	Bus: 5,001-12,000 lbs.	F	T
53	Bus: 12,001-18,000 lbs.	F	T
54	Bus: Over 18,000 lbs.	F	T
55	Tour Bus - All Weights	F	T
61	Farm Plates	F	F
63	Historic Vehicle - Normal Roadway Use (Passenger)	T	T
64	Historic Vehicle - Normal Roadway Use (Pickup)	T	T
65	Historic Vehicle - Normal Roadway Use (Motorcycle)	F	T
71	Snow Vehicles (2 year registration)	F	F
72	Snow Vehicles (4 year registration)	F	F
73	Snow Vehicles (6 year registration)	F	F
81	Prisoner of War Passenger	T	T
82	Prisoner of War Pickup and Van	T	T
83	Pearl Harbor Survivor Passenger	T	T
84	Pearl Harbor Survivor Pickup & Van	T	T
91	Commercial Passenger: Under 5,000 lbs.	T	T
92	Commercial Passenger: 5,001 - 12,000 lbs.	T	T
93	Commercial Passenger: 12,001 - 18,000 lbs.	F	T
94	Commercial Passenger: Over 18,000 lbs.	F	T
1A	Army Passenger	F	T
1B	Army Pickup	F	T
1C	Custom Collector Passenger	T	T
1D	Alaska Veteran Commemorative - Passenger	T	T
1F	Alaska Veteran Commemorative - Passenger	T	T
1G	Call Letter Passenger	T	T
1H	Government Exempt Passenger	T	T
1M	State Passenger	T	T
1P	Exempt Passenger (Charitable)	T	T

Alaska DMV Database – Class Code Scheme (cont.)

Class Code	Description	IM Required	On-Road Vehicle
2A	Navy Passenger	T	T
2B	Navy Pickup	T	T
2D	AK Veteran Commemorative - Pickup & Van	T	T
2G	Government Exempt Motorcycle	F	T
2H	State Motorcycle	F	T
2J	Motorcycle - Personalized Vet - Army	F	T
2K	Motorcycle - Personalized Vet - Navy	F	T
2M	Motorcycle - Personalized Vet - Marines	F	T
2N	Motorcycle - Personalized Vet - Air Force	F	T
2P	Exempt Motorcycle (Charitable)	F	T
2Q	Motorcycle - Personalized Vet - Coast Guard	F	T
3A	Marines Passenger	T	T
3B	Marines Pickup	T	T
3G	Government Exempt Non-Commercial Trailer	F	F
3H	State Non-Commercial Trailer	F	F
3P	Exempt Non-Commercial Trailer (Charitable)	F	F
4A	Air Force Passenger	T	T
4B	Air Force Pickup	T	T
4C	Custom Collector Pickup/Truck	T	T
4F	Call Letter Pickup & Van	T	T
4G	Government Exempt Pickup/Truck	T	T
4H	State Pickup Truck	T	T
4M	Government Personalized Pickup	T	T
4O	Non-Commercial Personalized Pickup	T	T
4P	Exempt Pickup/Truck (Charitable)	T	T
5A	Coast Guard Passenger	T	T
5B	Coast Guard Pickup	T	T
5G	Government Exempt Bus	F	T
5H	State Bus	F	T
5P	Exempt Bus (Charitable)	F	T
6A	National Guard Passenger	T	T
6B	National Guard Pickup	T	T
7A	Purple Heart Passenger	T	T
7B	Purple Heart Pickup	T	T
AA	UAA Passenger	T	T
AB	UAA Pickup	T	T
D1	Disabled Vet. Passenger (No Parking Logo-2nd Set)	T	T
D2	Disabled Veteran Pickup (No Parking Logo-2nd Set)	T	T
DC	Disabled Veteran Passenger (2nd Set)	T	T
DD	Disabled Veteran (1st Set)	T	T
DP	Disabled Veteran Pickup & Van (2nd Set)	T	T
DV	Disabled Veteran (No Parking Logo)	T	T
FA	UAF Passenger	T	T
FB	UAF Pickup	T	T
HC	Disability Passenger (2nd Set)	T	T
HH	Disability (1st Set)	T	T
HP	Disability Pickup & Van (2nd Set)	T	T
JA	UAS Passenger	T	T
JB	UAS Pickup	T	T
K1	Gold Star Family - Passenger	F	T
K2	Gold Star Family - Pickup	F	T
K4	Gold Star Family - Trailer	F	T
KA	Childrens Trust Passenger	T	T
KB	Childrens Trust Pickup	T	T
PA	PWS Passenger	T	T
PB	PWS Pickup	T	T
S1	Support our Troops Passenger	T	T
S2	Support our Troops Pickup	T	T
S3	Support our Troops Motorcycle	F	T
S4	Support our Troops Trailer	F	T

Alaska DMV Database – Body Style Scheme

State of Alaska **Division of Motor Vehicles** **Standard Operating Procedures**	**SOP No.: T** **Appendix C**	**Page No.: 1**
	Effective: April 14, 2006	
Subject:	**Supersedes:**	**Dated: NEW**
BODY STYLES	**Form No.:**	
Statute: AS	**Regulation: AAC**	

See Table PR-VBODY (Table 41) for additional body styles.

TV	5th Wheel	**FB**	Snowmachine Trailer
AE	Aerial Platform	**ME**	Special Mobile Equipment
AI	Air Compressor	**SY**	Sprayer
AM	Ambulance	**ST**	Stake
AR	Armored Truck	**SW**	Station Wagon
AD	Asphalt Distributor	**SI**	Striper
AC	Auto Carrier	**SS**	Sweeper
BH	Backhoe/Loader	**FC**	Flotation Chassis
BG	Baggage	**FW**	Food Wagon
BR	Beverage Rack	**FL**	Fork Lift
BT	Boat	**ST**	Frame
BC	Brush Chipper	**GG**	Garbage or Refuse
BG	Buggy, Concrete	**GE**	Generator
BD	Bulldozer	**GR**	Glass Rack
BU	Bus	**GD**	Grader
CL	Cable Reel	**HO**	Grain (Hopper)
CT	Camping	**GN**	Grain
AC	Car Carrier	**HM**	Hammer
VN	Cargo	**2H**	Hardtop, 2 Door
LL	Carry-All / SUV	**4H**	Hardtop, 4 Door
CB	Chassis Cab	**HV**	Harvester
CO	Combine	**HB**	Hatchback (3 door & 5 door)
CM	Concrete Mixer	**HL**	Hay Bale Loader
CV	Convertible	**HY**	Hay Baler
CI	Corn Picker	**HR**	Hearse
CK	Cotton Picker	**HO**	Hopper
CZ	Cotton Stripper	**HE**	Horse
CP	Coupe	**LF**	Lift Boom

CR	Crane	**LM**	Limousine
DE	Detasseling Equipment	**LC**	Line Construction
DR	Drill, Rock	**LS**	Livestock Rack
DP	Dump	**LD**	Loader
EX	Excavator	**LK**	Log Skidder
FS	Fertilizer Spreader	**LP**	Log
FD	Field Chopper	**LB**	Lowbed
TV	Fifth Wheel	**LB**	Lowboy
FT	Fire Truck	**BG**	Luggage
FB	Flatbed	**LW**	Lunch Wagon
FR	Flatrack	**MB**	Moped
MR	Mower, Grass or Hay	**MB**	Motor Scooter
MR	Mower, Conditioner	**MB**	Motorbike
MO	Mower, Garden Tractor	**FB**	Motorcycle Trailer
MO	Mower, Riding	**MC**	Motorcycle
OF	Office	**MH**	Motorhome
PL	Pallet	**TN**	Tank
PN	Panel	**TN**	Tanker
VP	Passenger Van	**TE**	Tent
PV	Paver	**TT**	Tow Truck
PK	Pickup	**TC**	Tractor, Track Type
FB	Platform	**DS**	Tractor, Truck (Diesel)
LP	Pole	**TR**	Tractor, Truck (Gas)
DI	Potato Digger	**TF**	Tractor, Wheel Type
PR	Prime Mover	**TV**	Travel
ST	Rack	**TA**	Tree Harvester
RF	Refrigerated Van	**UT**	Utility Trailer
RF	Refrigerator	**LL**	Utility Vehicle
RD	Roadster	**VA**	Vacuum Cleaner
RO	Roller	**VN**	Van (Cargo)
SZ	Saw	**VC**	Van Camper
SC	Scraper	**VP**	Van, Passenger
2D	Sedan, 2 Door	**VT**	Vanette
4D	Sedan, 4 Door	**WE**	Welder
UT	Service	**WD**	Well Driller
SP	Shipping Container	**WN**	Windrower
SH	Shovel	**TT**	Wrecker
SO	Snowblower		

Alaska VIN Decoder – Key Field Descriptions

VEHICLE CLASS

CITY TRANSIT BUS
DUAL SPORT
FULL-SIZE MPV
FULL-SIZE PICKUP
FULL-SIZE VAN
INTERCITY/TOUR BUS
LARGE CAR
MID-SIZE CAR
MID-SIZE MPV
MILITARY
MINI BUS
MINI PICKUP
MINI VAN
ON ROAD MOTORCYCLE
SCHOOL BUS
SCOOTER
SMALL CAR
SMALL MPV
TRUCK DELIVERY
TRUCK TRACTOR
UTILITY VAN

GVWR CLASS

CLASS A: 0-3 000 LB
CLASS B: 3 001-4 000 LB
CLASS C: 4 001-5 000 LB
CLASS D: 5 001-6 000 LB
CLASS E: 6 001-7 000 LB
CLASS F: 7 001-8 000 LB
CLASS G: 8 001-9 000 LB
CLASS H: 9 001-10 000 LB
CLASS 3: 10 001-14 000 LB
CLASS 4: 14 001-16 000 LB
CLASS 5: 16 001-19 500 LB
CLASS 6: 19 501-26 000 LB
CLASS 7: 26 001-33 000 LB
CLASS 8: 33 001 LB AND OVER

Alaska VIN Decoder – Key Field Descriptions (cont.)

VEHICLE TYPE

BUS
INCOMPLETE VEHICLE
MOTORCYCLE
MULTIPURPOSE VEHICLE (MPV)
PASSENGER CAR
PICKUP TRUCK
RECREATIONAL VEHICLE
TRUCK
VAN

BODY TYPE

2 DOOR CAB
2 DOOR CAB; CHASSIS
2 DOOR CAB; CHASSIS; CONVENTIONAL
2 DOOR CAB; CLUB
2 DOOR CAB; CLUB; LONG BED
2 DOOR CAB; CREW
2 DOOR CAB; EXTENDED
2 DOOR CAB; EXTENDED; CHASSIS
2 DOOR CAB; EXTENDED; PLUS
2 DOOR CAB; KING CAB
2 DOOR CAB; LONG BED
2 DOOR CAB; PLUS
2 DOOR CAB; REGULAR
2 DOOR CAB; REGULAR; CHASSIS
2 DOOR CAB; REGULAR; FLARESIDE
2 DOOR CAB; REGULAR; LONG BED
2 DOOR CAB; REGULAR; SHORT BED
2 DOOR CAB; REGULAR; STYLESIDE
2 DOOR CAB; REGULAR; SUNDOWNER
2 DOOR CAB; REGULAR; SUNDOWNER; LONG BED
2 DOOR CAB; REGULAR; TOWNSIDE
2 DOOR CAB; SHORT BED
2 DOOR CAB; SHORT BED; SWEPTLINE
2 DOOR CAB; SPACE
2 DOOR CAB; SUPER CAB
2 DOOR CAB; SUPER LONG BED
2 DOOR CAB; SWEPTLINE
2 DOOR CAB; SWEPTLINE; CHASSIS
2 DOOR CAB; X-CAB

2 DOOR CAB; X-CAB; LONG BED
2 DOOR CONVERTIBLE
2 DOOR CONVERTIBLE; OPEN TOP
2 DOOR CONVERTIBLE; ROADSTER
2 DOOR COUPE
2 DOOR COUPE; HARD TOP
2 DOOR COUPE; LIFTBACK
2 DOOR COUPE; NOTCHBACK
2 DOOR COUPE; SPORT ROOF
2 DOOR COUPE; TARGA
2 DOOR HATCHBACK
2 DOOR HATCHBACK; LIFTBACK
2 DOOR HATCHBACK; SPORT ROOF
2 DOOR HATCHBACK; SPORTWAGON
2 DOOR VAN
2 DOOR WAGON
2 DOOR WAGON; CANVAS TOP
2 DOOR WAGON; HARD TOP
2 DOOR WAGON; OPEN BODY
2 DOOR WAGON; SHORT WHEELBASE
2 DOOR WAGON; T-BAR TOP
2 PERSON
2/4 DOOR WAGON
200 WIDE BODY VAN
2-PASSENGER
3 DOOR BUS
3 DOOR CAB; SUPER CAB; FLARESIDE
3 DOOR CAB; SUPER CAB; STYLESIDE
3 DOOR VAN
3 DOOR VAN; CARGO
3 DOOR VAN; CHASSIS
3 DOOR VAN; CUTAWAY
3 DOOR VAN; EXTENDED
3 DOOR VAN; EXTENDED; CARGO
3 DOOR VAN; EXTENDED; PASSENGER
3 DOOR VAN; EXTENDED; SPORT
3 DOOR VAN; EXTENDED; WINDOW
3 DOOR VAN; INCOMPLETE CHASSIS
3 DOOR VAN; PASSENGER
3 DOOR VAN; REGULAR; CARGO
3 DOOR VAN; SPORT
3 DOOR VAN; SUPER EXTENDED; CARGO
3 DOOR VAN; SUPER EXTENDED; DISPLAY
3 DOOR VAN; SUPER EXTENDED; WINDOW
4 DOOR CAB; ACCESS CAB
4 DOOR CAB; CHASSIS

4 DOOR CAB; CHASSIS; CREW
4 DOOR CAB; CLUB
4 DOOR CAB; CREW
4 DOOR CAB; CREW MAX
4 DOOR CAB; CREW; LONG BED
4 DOOR CAB; CREW; LONG WHEELBASE
4 DOOR CAB; CREW; SHORT WHEELBASE
4 DOOR CAB; DOUBLE CAB
4 DOOR CAB; DOUBLE CAB; LONG BED
4 DOOR CAB; DOUBLE CAB; STANDARD BED
4 DOOR CAB; EXTENDED
4 DOOR CAB; EXTENDED; CHASSIS
4 DOOR CAB; EXTENDED; QUAD
4 DOOR CAB; EXTENDED; QUAD; CHASSIS
4 DOOR CAB; EXTENDED; UTILITY
4 DOOR CAB; FLARESIDE; SUPER CREW
4 DOOR CAB; KING CAB
4 DOOR CAB; KING CAB; LONG WHEELBASE
4 DOOR CAB; KING CAB; SHORT WHEELBASE
4 DOOR CAB; MEGA
4 DOOR CAB; PLUS
4 DOOR CAB; QUAD
4 DOOR CAB; REGULAR
4 DOOR CAB; STYLESIDE; SUPER CREW
4 DOOR CAB; SUPER CAB
4 DOOR CAB; SUPER CAB; CHASSIS
4 DOOR CAB; SUPER CAB; FLARESIDE
4 DOOR CAB; SUPER CAB; STYLESIDE
4 DOOR CAB; SUPER CREW
4 DOOR CAB; UTILITY
4 DOOR COUPE
4 DOOR HATCHBACK
4 DOOR HATCHBACK; LIFTBACK
4 DOOR SEDAN
4 DOOR SEDAN; HARD TOP
4 DOOR SEDAN; LIFTBACK
4 DOOR SEDAN; LONG WHEELBASE
4 DOOR SEDAN; SHORT WHEELBASE
4 DOOR VAN
4 DOOR VAN; CARGO
4 DOOR VAN; EXTENDED
4 DOOR VAN; EXTENDED; CARGO
4 DOOR VAN; EXTENDED; PASSENGER
4 DOOR VAN; PASSENGER
4 DOOR VAN; REGULAR
4 DOOR WAGON

4 DOOR WAGON; ALL PURPOSE WINDOW-LIFT GATE
4 DOOR WAGON; HARD TOP
4 DOOR WAGON; SPORT
4 DOOR WAGON; STATION WAGON
BASE
BASE CUTAWAY; CUBE VAN
CHASSIS
CHASSIS CAB
CHOPPER
CLASS A MOTORHOME CHASSIS; STRIPPED CHASSIS
COMMERCIAL BASIC STRIPPED CHASSIS
COMMERCIAL CHASSIS
COMMERCIAL CUTAWAY
COMMERCIAL CUTAWAY; VAN
COMMERCIAL SPECIAL AND RV CUTAWAY
COMMERCIAL STRIPPED CHASSIS
CONCRETE OR TRANSIT MIXER
CONSTRUCTION
CONSTRUCTION; STEEL CAB
CREW CAB
CUBE VAN
CUSTOM
CUTAWAY
DELUXE
DUMP
EXPERIMENTAL
EXTENDED; CLUB WAGON
FORWARD CONTROL
FORWARD CONTROL BODY
FORWARD/TILTMASTER
HEAVY WEIGHT
HIGHWAY
HIGHWAY; STEEL CAB
INTEGRATED CE COMMERCIAL BUS
INTEGRATED CONVENTIONAL BUS
INTERCITY BUS
INTERCITY COACH
LOWERED RAIL REAR ENGINE
MEDIUM CONVENTIONAL
MEDIUM STEEL TILT
MIDDLE WEIGHT
MOTOR HOME
MOTOR HOME CHASSIS
MOTOR HOME STRIPPED CHASSIS
MOTORIZED CUTAWAY
REAR ENGINE

REGULAR
REGULAR CAB
RV CUTAWAY
RV STRIPPED CHASSIS
SIDE CAR
SINGLE DOWN TUBE
SOFTAIL
SPECIAL COMMERCIAL CHASSIS
SPORT
SPORT BIKE
STANDARD
STEP VAN
STRIPPED CHASSIS
SUPER CAB
SUPER DUTY CUTAWAY; VAN
THREE-WHEEL FOR PASSEGER

MOVES Age Distribution Inputs

May 2010 DMV & Winter 2009 Parking Survey Based Vehicle Fractions by MOVES Source Use Type and Age

	MC	PC	PT	LCT	ICTYBUS	TRNBUS	SCHBUS	REFTRK	Single-Unit Truck		MtrHome	Combo-Unit Truck	
									ShortHaul	LongHaul		ShortHaul	LongHaul
Source:	**SURVEY**	**SURVEY**	**SURVEY**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**	**DMV**
Age	**11**	**21**	**31**	**32**	**41**	**42**	**43**	**51**	**52**	**53**	**54**	**61**	**62**
0	0.0000	0.0529	0.0427	0.0433	0.0000	0.0000	0.0000	0.0294	0.0017	0.0017	0.0000	0.0328	0.0328
1	0.0000	0.0706	0.0569	0.0629	0.0000	0.0189	0.0215	0.4412	0.0150	0.0150	0.0000	0.0361	0.0361
2	0.0000	0.0739	0.0764	0.1211	0.0000	0.1321	0.0511	0.0294	0.0341	0.0341	0.0111	0.0270	0.0270
3	0.0000	0.0686	0.0861	0.0864	0.0000	0.1887	0.3199	0.0000	0.0599	0.0599	0.0090	0.0672	0.0672
4	0.0000	0.0856	0.0906	0.0986	0.0408	0.0189	0.0323	0.0588	0.0499	0.0499	0.0263	0.0639	0.0639
5	1.0000	0.0503	0.0847	0.0664	0.0102	0.0000	0.0484	0.0000	0.0474	0.0474	0.0216	0.0443	0.0443
6	0.0000	0.0675	0.0839	0.0575	0.0102	0.0189	0.0457	0.0000	0.0333	0.0333	0.0279	0.0156	0.0156
7	0.0000	0.0664	0.0691	0.0548	0.1429	0.0189	0.0269	0.0882	0.0341	0.0341	0.0184	0.0303	0.0303
8	0.0000	0.0556	0.0547	0.0392	0.0408	0.0000	0.0108	0.0294	0.0274	0.0274	0.0269	0.0377	0.0377
9	0.0000	0.0620	0.0604	0.0436	0.0510	0.0189	0.0296	0.0000	0.0366	0.0366	0.0258	0.0418	0.0418
10	0.0000	0.0525	0.0557	0.0550	0.1531	0.0000	0.0323	0.0588	0.0507	0.0507	0.0348	0.0352	0.0352
11	0.0000	0.0483	0.0425	0.0365	0.1020	0.0189	0.0323	0.0294	0.0407	0.0407	0.0532	0.0557	0.0557
12	0.0000	0.0495	0.0340	0.0216	0.0102	0.0000	0.0591	0.0294	0.0449	0.0449	0.0327	0.0426	0.0426
13	0.0000	0.0278	0.0249	0.0317	0.1531	0.0000	0.0323	0.0000	0.0407	0.0407	0.0448	0.0361	0.0361
14	0.0000	0.0325	0.0282	0.0249	0.0306	0.0000	0.0484	0.0882	0.0357	0.0357	0.0385	0.0410	0.0410
15	0.0000	0.0219	0.0292	0.0212	0.0612	0.0189	0.0081	0.0000	0.0283	0.0283	0.0448	0.0385	0.0385
16	0.0000	0.0231	0.0205	0.0190	0.0306	0.0566	0.0242	0.0000	0.0366	0.0366	0.0501	0.0344	0.0344
17	0.0000	0.0217	0.0118	0.0163	0.0000	0.1132	0.0269	0.0294	0.0258	0.0258	0.0300	0.0254	0.0254
18	0.0000	0.0194	0.0126	0.0095	0.0000	0.0000	0.0161	0.0000	0.0274	0.0274	0.0348	0.0303	0.0303
19	0.0000	0.0189	0.0083	0.0125	0.0204	0.0943	0.0108	0.0000	0.0216	0.0216	0.0248	0.0246	0.0246
20	0.0000	0.0075	0.0059	0.0109	0.0102	0.0377	0.0161	0.0000	0.0224	0.0224	0.0316	0.0352	0.0352
21	0.0000	0.0056	0.0047	0.0057	0.0306	0.0377	0.0269	0.0294	0.0200	0.0200	0.0416	0.0270	0.0270
22	0.0000	0.0047	0.0024	0.0063	0.0102	0.0000	0.0134	0.0000	0.0150	0.0150	0.0437	0.0164	0.0164
23	0.0000	0.0031	0.0028	0.0029	0.0204	0.1132	0.0054	0.0000	0.0083	0.0083	0.0332	0.0172	0.0172
24	0.0000	0.0028	0.0020	0.0046	0.0000	0.0000	0.0027	0.0000	0.0200	0.0200	0.0237	0.0107	0.0107
25	0.0000	0.0028	0.0022	0.0065	0.0000	0.0377	0.0215	0.0294	0.0158	0.0158	0.0295	0.0098	0.0098
26	0.0000	0.0019	0.0012	0.0052	0.0000	0.0189	0.0027	0.0000	0.0216	0.0216	0.0274	0.0115	0.0115
27	0.0000	0.0003	0.0000	0.0038	0.0000	0.0000	0.0161	0.0000	0.0091	0.0091	0.0142	0.0082	0.0082
28	0.0000	0.0003	0.0010	0.0030	0.0306	0.0000	0.0027	0.0000	0.0258	0.0258	0.0200	0.0115	0.0115
29	0.0000	0.0006	0.0004	0.0019	0.0102	0.0189	0.0027	0.0000	0.0125	0.0125	0.0095	0.0213	0.0213
30+	0.0000	0.0017	0.0043	0.0271	0.0306	0.0189	0.0134	0.0294	0.1380	0.1380	0.1702	0.0705	0.0705
All	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Calculation of VMT Allocations by HPMS Vehicle Type Category

Calculation of VMT by HPMS Vehicle Type by Apportioning DMV-Based Estimates to TransCAD Modeled VMT

	TransCAD PM Area Daily VMT 2010	2035
Entire Fleet:	**1,823,895**	**2,388,715**
LDVs (11,21,31):	1,718,763	2,284,514
TRKs (32+):	105,132	104,201
LDV%:	94.2%	95.6%
TRK%:	5.8%	4.4%

HPMSVtypeID	SourceTypes	MOVESDflt Miles/Yr/Veh	Fairbanks Popn	Fairbanks VMT/Yr	DMV-Based Fairbanks VMT/Day	Aggregated DMV-Based VMT/Day	2010 Base TransCAD VMT/Day	2010 Base DMV/TransCAD Ratio	2010 Base TransCAD DMV Apportioned VMT/Day	2010 Base TransCAD DMV Apportioned VMT/Yr	2035 LRTP TransCAD VMT/Day	2035 LRTP DMV/TransCAD Ratio	2035 LRTP TransCAD DMV Apportioned VMT/Day	2035 LRTP TransCAD DMV Apportioned VMT/Yr
10	11	2,540	4,234	10,752,707	29,459				20,335	**7,422,302**			27,029	**9,865,440**
20	21	12,051	25,441	306,598,421	839,996	2,489,976	1,718,763	1.449	579,826	**211,636,581**	2,284,514	1.090	770,683	**281,299,235**
30	31	11,806	50,102	591,490,107	1,620,521				1,118,602	**408,289,591**			1,486,802	**542,682,883**
30	32	11,806	6,309	74,482,278	204,061				38,392	**14,013,009**			38,052	**13,888,854**
40	41,42,43	10,458	523	5,469,368	14,985	558,802	105,132	5.315	2,819	**1,029,000**	104,201	5.363	2,794	**1,019,884**
50	51,52,53,54	12,271	3,135	38,469,721	105,396				19,829	**7,237,648**			19,653	**7,173,523**
60	61,62	70,116	1,220	85,541,220	234,360				44,092	**16,093,625**			43,701	**15,951,036**
			90,964	1,112,803,821	**3,048,778**				**1,823,895**	**665,721,757**			**2,388,715**	**871,880,854**

Resulting Annual VMT for MOVES Input

HPMSVtypeID	Annual VMT (Miles/Year) **2010**	2015	2025	**2035**
10	**7,422,302**	7,910,930	8,888,185	**9,865,440**
20	**211,636,581**	225,569,112	253,434,173	**281,299,235**
30	**422,302,600**	449,156,427	502,864,082	**556,571,737**
40	**1,029,000**	1,027,177	1,023,530	**1,019,884**
50	**7,237,648**	7,224,823	7,199,173	**7,173,523**
60	**16,093,625**	16,065,107	16,008,072	**15,951,036**
	665,721,757	706,953,576	789,417,215	**871,880,854**
VMT/Day:	**1,823,895**	**1,936,859**	**2,162,787**	**2,388,715**

Scaled Vehicle Populations
(from 2010, keeping annual mileage constant)

SourceType	**2010**	2015	2025	**2035**
11	**4,234**	4,513	5,070	**5,628**
21	**25,441**	27,116	30,466	**33,815**
31	**50,102**	53,288	59,660	**66,032**
32	**6,309**	6,710	7,513	**8,315**
41	**98**	98	97	**97**
42	**53**	53	53	**53**
43	**372**	371	370	**369**
51	**34**	34	34	**34**
52	**1,100**	1,098	1,094	**1,090**
53	**103**	103	103	**102**
54	**1,898**	1,895	1,888	**1,881**
61	**694**	693	690	**688**
62	**526**	525	523	**521**
All	**90,964**	96,496	107,560	**118,624**

Normalized Speed Distribution Inputs by Road Type and Time of Day

2010 AM Peak (7-9 am, MOVES Hrs 8-10)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00408
4	15	0.00000	0.00000	0.00000	0.00000	0.03268
5	20	0.00000	0.00000	0.00089	0.00250	0.05518
6	25	0.00000	0.00000	0.23859	0.00000	0.23790
7	30	0.00000	0.06093	0.44354	0.16503	0.20091
8	35	0.00000	0.00066	0.10390	0.07915	0.23961
9	40	0.00000	0.00000	0.07377	0.00000	0.04823
10	45	0.00000	0.00000	0.06820	0.00000	0.01249
11	50	0.00000	0.93841	0.07111	0.75332	0.16891
12	55	0.00000	0.00000	0.00000	0.00000	0.00000
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2035 AM Peak (7-9 am, MOVES Hrs 8-10)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.01324
4	15	0.00000	0.00000	0.00000	0.00000	0.02056
5	20	0.00000	0.00000	0.00000	0.00358	0.07247
6	25	0.00000	0.00000	0.22983	0.00000	0.24639
7	30	0.00000	0.06755	0.45523	0.18655	0.20494
8	35	0.00000	0.00057	0.10975	0.07692	0.17352
9	40	0.00000	0.00000	0.07007	0.00000	0.05085
10	45	0.00000	0.00000	0.06075	0.00000	0.00676
11	50	0.00000	0.93188	0.07437	0.73295	0.21127
12	55	0.00000	0.00000	0.00000	0.00000	0.00000
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2010 PM Peak (3-6 pm, MOVES Hrs 16-19)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00170
4	15	0.00000	0.00000	0.00102	0.00000	0.03214
5	20	0.00000	0.00000	0.00000	0.00297	0.05386
6	25	0.00000	0.00000	0.24474	0.00000	0.23253
7	30	0.00000	0.06716	0.46657	0.21186	0.21577
8	35	0.00000	0.00064	0.10502	0.04680	0.24191
9	40	0.00000	0.00000	0.06596	0.00000	0.06176
10	45	0.00000	0.00000	0.05800	0.00000	0.01289
11	50	0.00000	0.93219	0.05869	0.73837	0.14744
12	55	0.00000	0.00000	0.00000	0.00000	0.00000
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2035 PM Peak (3-6 pm, MOVES Hrs 16-19)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00804
4	15	0.00000	0.00000	0.00000	0.00000	0.02339
5	20	0.00000	0.00000	0.00000	0.00288	0.06666
6	25	0.00000	0.00000	0.23269	0.00000	0.24352
7	30	0.00000	0.07206	0.48234	0.19768	0.21732
8	35	0.00000	0.00060	0.10819	0.06229	0.19075
9	40	0.00000	0.00000	0.06223	0.00000	0.05290
10	45	0.00000	0.00000	0.05188	0.00000	0.00713
11	50	0.00000	0.92733	0.06268	0.73716	0.19028
12	55	0.00000	0.00000	0.00000	0.00000	0.00000
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2010 Off Peak (9 am-3 pm, 7 pm-7 am, MOVES Hrs 10-15, 20-7)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00243
4	15	0.00000	0.00000	0.00000	0.00000	0.00049
5	20	0.00000	0.00000	0.00119	0.00201	0.08816
6	25	0.00000	0.00000	0.23781	0.00000	0.17161
7	30	0.00000	0.06749	0.00502	0.25648	0.10135
8	35	0.00000	0.00000	0.43450	0.01507	0.23485
9	40	0.00000	0.00375	0.10244	0.04457	0.20932
10	45	0.00000	0.00000	0.10756	0.00000	0.05043
11	50	0.00000	0.00000	0.03843	0.00000	0.01101
12	55	0.00000	0.92875	0.07305	0.68187	0.13035
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2035 Off Peak (9 am-3 pm, 7 pm-7 am, MOVES Hrs 10-15, 20-7)

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00628
4	15	0.00000	0.00000	0.00000	0.00000	0.00022
5	20	0.00000	0.00000	0.00000	0.00320	0.04706
6	25	0.00000	0.00000	0.20797	0.00000	0.22205
7	30	0.00000	0.06430	0.00403	0.24969	0.09707
8	35	0.00000	0.00000	0.52306	0.01820	0.23529
9	40	0.00000	0.00066	0.12083	0.03749	0.17753
10	45	0.00000	0.00000	0.04355	0.00000	0.04588
11	50	0.00000	0.00000	0.04697	0.00000	0.00843
12	55	0.00000	0.93504	0.05358	0.69141	0.16019
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2010 Truck Daily Values

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.01059
4	15	0.00000	0.00000	0.00000	0.00000	0.00899
5	20	0.00000	0.00000	0.00209	0.00184	0.07887
6	25	0.00000	0.00000	0.20731	0.00000	0.16862
7	30	0.00000	0.02024	0.01155	0.17486	0.18614
8	35	0.00000	0.00000	0.39595	0.01268	0.11020
9	40	0.00000	0.00298	0.08689	0.03191	0.23276
10	45	0.00000	0.00000	0.14801	0.00000	0.06691
11	50	0.00000	0.56125	0.02656	0.34358	0.03021
12	55	0.00000	0.41553	0.12164	0.43513	0.10670
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

2035 Truck Daily Values

SpdBin	SpdRange	Off-Network 1	Rural Rstrcd 2	Rural Unrstctd 3	Urban Rstrcd 4	Urban Unrstctd 5
1	2.5	0.00000	0.00000	0.00000	0.00000	0.00000
2	5	0.00000	0.00000	0.00000	0.00000	0.00000
3	10	0.00000	0.00000	0.00000	0.00000	0.00554
4	15	0.00000	0.00000	0.00000	0.00000	0.00060
5	20	0.00000	0.00000	0.00000	0.00116	0.07091
6	25	0.00000	0.00000	0.15554	0.00000	0.17987
7	30	0.00000	0.02380	0.00505	0.22252	0.15781
8	35	0.00000	0.00000	0.45527	0.01640	0.15516
9	40	0.00000	0.00536	0.11451	0.05217	0.16693
10	45	0.00000	0.00000	0.10795	0.00000	0.05651
11	50	0.00000	0.00000	0.02947	0.13446	0.06469
12	55	0.00000	0.97084	0.13222	0.57328	0.14197
13	60	0.00000	0.00000	0.00000	0.00000	0.00000
14	65	0.00000	0.00000	0.00000	0.00000	0.00000
15	70	0.00000	0.00000	0.00000	0.00000	0.00000
16	75	0.00000	0.00000	0.00000	0.00000	0.00000
	CheckSum:	**0.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**

Tabulated Road Type VMT by Time of Day and Normalized Road Type Distribution Inputs by Time of Day

2010 Base VMT by MOVES Road Type and Normalized

	Off-Network	Rural Rstrcd	Rural Unrstctd	Urban Rstrcd	Urban Unrstctd			Off-Network	Rural Rstrcd	Rural Unrstctd	Urban Rstrcd	Urban Unrstctd
	1	2	3	4	5	CheckSum		1	2	3	4	5
Sum of DVMT		225,452	852,272	250,226	495,946	1,823,895	Sum of DVMT	0.000	0.124	0.467	0.137	0.272
Sum of AVMT		21,137	57,217	21,378	32,737	132,469	Sum of AVMT	0.000	0.160	0.432	0.161	0.247
Sum of PVMT		46,770	179,362	53,288	100,715	380,135	Sum of PVMT	0.000	0.123	0.472	0.140	0.265
Sum of OVMT		141,990	575,088	148,557	340,524	1,206,159	Sum of OVMT	0.000	0.118	0.477	0.123	0.282
Sum of TRKVMT		15,555	40,604	27,003	21,970	105,132	Sum of TRKVM	0.000	0.148	0.386	0.257	0.209

2035 Forecast VMT by MOVES Road Type and Normalized

	Off-Network	Rural Rstrcd	Rural Unrstctd	Urban Rstrcd	Urban Unrstctd			Off-Network	Rural Rstrcd	Rural Unrstctd	Urban Rstrcd	Urban Unrstctd
	1	2	3	4	5	CheckSum		1	2	3	4	5
Sum of DVMT		337,118	703,148	263,617	1,072,687	2,376,571	Sum of DVMT	0.000	0.142	0.296	0.111	0.451
Sum of AVMT		28,174	41,997	23,434	78,947	172,551	Sum of AVMT	0.000	0.163	0.243	0.136	0.458
Sum of PVMT		66,284	126,598	54,151	219,014	466,047	Sum of PVMT	0.000	0.142	0.272	0.116	0.470
Sum of OVMT		202,975	484,880	168,770	712,351	1,568,977	Sum of OVMT	0.000	0.129	0.309	0.108	0.454
Sum of TRKVMT		39,685	49,673	17,261	62,376	168,996	Sum of TRKVM	0.000	0.235	0.294	0.102	0.369

Attachment D

NONROAD Model Outputs

2008 NONROAD SOURCE WINTER SEASON EMISSIONS AND MONTHLY ALLOCATIONS (May/June 2013 NONROAD Runs)

County Name	SOURCE DESCRIPTION	SCC	ANNUAL EMISSIONS (tons/year) VOC	CO	NOX	SOX	PM10-PRI	PM25-PRI	NH3	WINTER PM MODELING EPISODE FRACTION VOC	CO	NOX	SOX	PM10-PRI	PM25-PRI	NH3
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Motorcycles: Off-road	2260001010	25.65	25.02	0.07	0.00	0.92	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Snowmobiles	2260001020	55.34	132.47	0.49	0.04	1.26	1.16	0.01	0.93	1.00	1.00	1.00	1.00	1.00	1.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, All Terrain Vehicles	2260001030	12.69	12.87	0.04	0.00	0.45	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2260001060	0.18	2.91	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Tampers/Rammers	2260002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Plate Compactors	2260002009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Paving Equipment	2260002021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2260002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2260002039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2260002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Sweepers/Scrubbers	2260003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Other General Industrial Equipment	2260003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2260004015	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2260004016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Residential)	2260004020	0.12	0.36	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Commercial)	2260004021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2260004025	0.15	0.47	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2260004026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2260004030	0.12	0.31	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2260004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2260004035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2260004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2260004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Agricultural Equipment, Sprayers	2260005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Generator Sets	2260006005	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Pumps	2260006010	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Air Compressors	2260006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Hydro-power Units	2260006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Logging Equipment, Chain Saws > 6 HP	2260007005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Motorcycles: Off-road	2265001010	1.12	10.04	0.13	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, All Terrain Vehicles	2265001030	11.78	93.49	1.11	0.02	0.13	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Golf Carts	2265001050	1.00	25.67	0.31	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2265001060	0.15	3.42	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Pavers	2265002003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tampers/Rammers	2265002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Plate Compactors	2265002009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rollers	2265002015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Paving Equipment	2265002021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Surfacing Equipment	2265002024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2265002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Trenchers	2265002030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Bore/Drill Rigs	2265002033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2265002039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cement and Mortar Mixers	2265002042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cranes	2265002045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2265002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rough Terrain Forklifts	2265002057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rubber Tire Loaders	2265002060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2265002066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Skid Steer Loaders	2265002072	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Dumpers/Tenders	2265002078	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Other Construction Equipment	2265002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Aerial Lifts	2265003010	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.35	0.43	0.60	0.45	0.45	0.45	0.45

Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Forklifts	2265003020	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.44	0.43	0.60	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Sweepers/Scrubbers	2265003030	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.41	0.43	0.60	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other General Industrial Equipment	2265003040	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.45	0.43	0.60	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Material Handling Equipment	2265003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.43	0.60	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, AC\Refrigeration	2265003060	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Terminal Tractors	2265003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.43	0.60	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Residential)	2265004010	0.79	7.38	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Commercial)	2265004011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2265004015	0.07	0.65	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2265004016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2265004025	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2265004026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2265004030	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2265004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2265004035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2265004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Residential)	2265004040	0.09	1.27	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Commercial)	2265004041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Front Mowers (Commercial)	2265004046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Shredders < 6 HP (Commercial)	2265004051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Residential)	2265004055	0.85	16.86	0.20	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2265004056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2265004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2265004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Residential)	2265004075	0.06	0.74	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2265004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, 2-Wheel Tractors	2265005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Tractors	2265005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Combines	2265005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Balers	2265005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Mowers	2265005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Sprayers	2265005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Tillers > 6 HP	2265005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Swathers	2265005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Other Agricultural Equipment	2265005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Irrigation Sets	2265005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Generator Sets	2265006005	0.14	2.84	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pumps	2265006010	0.04	0.57	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Air Compressors	2265006015	0.01	0.25	0.01	0.00	0.00	0.00	0.00	0.48	0.47	0.67	0.50	0.50	0.50	0.50
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Welders	2265006025	0.02	0.63	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pressure Washers	2265006030	0.07	1.19	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Hydro-power Units	2265006035	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Shredders > 6 HP	2265007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2265007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Airport Ground Support Equipment, Airport Ground Support Equipment	2265008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Oil Field Equipment	2265010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Recreational Equipment, Specialty Vehicles/Carts	2267001060	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Pavers	2267002003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Rollers	2267002015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Paving Equipment	2267002021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Surfacing Equipment	2267002024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Trenchers	2267002030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Bore/Drill Rigs	2267002033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Concrete/Industrial Saws	2267002039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Cranes	2267002045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Crushing/Processing Equipment	2267002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Rough Terrain Forklifts	2267002057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Rubber Tire Loaders	2267002060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Denali	Mobile Sources, LPG, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2267002066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Skid Steer Loaders	2267002072	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Construction and Mining Equipment, Other Construction Equipment	2267002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Industrial Equipment, Aerial Lifts	2267003010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Industrial Equipment, Forklifts	2267003020	0.01	0.24	0.04	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Industrial Equipment, Sweepers/Scrubbers	2267003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Industrial Equipment, Other General Industrial Equipment	2267003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Industrial Equipment, Other Material Handling Equipment	2267003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Industrial Equipment, Terminal Tractors	2267003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, LPG, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2267004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Agricultural Equipment, Other Agricultural Equipment	2267005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Agricultural Equipment, Irrigation Sets	2267005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Commercial Equipment, Generator Sets	2267006005	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Commercial Equipment, Pumps	2267006010	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Commercial Equipment, Air Compressors	2267006015	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, LPG, Commercial Equipment, Welders	2267006025	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Commercial Equipment, Pressure Washers	2267006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Commercial Equipment, Hydro-power Units	2267006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, LPG, Airport Ground Support Equipment, Airport Ground Support Equipment	2267008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Construction and Mining Equipment, Other Construction Equipment	2268002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Industrial Equipment, Forklifts	2268003020	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, CNG, Industrial Equipment, Sweepers/Scrubbers	2268003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Industrial Equipment, Other General Industrial Equipment	2268003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Industrial Equipment, AC\Refrigeration	2268003060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Industrial Equipment, Terminal Tractors	2268003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Agricultural Equipment, Other Agricultural Equipment	2268005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Agricultural Equipment, Irrigation Sets	2268005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Commercial Equipment, Generator Sets	2268006005	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Commercial Equipment, Pumps	2268006010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Commercial Equipment, Air Compressors	2268006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, CNG, Commercial Equipment, Gas Compressors	2268006020	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, CNG, Commercial Equipment, Hydro-power Units	2268006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, CNG, Industrial Equipment, Other Oil Field Equipment	2268010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Recreational Equipment, Specialty Vehicles/Carts	2270001060	0.03	0.10	0.09	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Pavers	2270002003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tampers/Rammers	2270002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Plate Compactors	2270002009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rollers	2270002015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Scrapers	2270002018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Paving Equipment	2270002021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Surfacing Equipment	2270002024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Signal Boards/Light Plants	2270002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Trenchers	2270002030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Bore/Drill Rigs	2270002033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Excavators	2270002036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Concrete/Industrial Saws	2270002039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cement and Mortar Mixers	2270002042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cranes	2270002045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Graders	2270002048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Trucks	2270002051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crushing/Processing Equipment	2270002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rough Terrain Forklifts	2270002057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rubber Tire Loaders	2270002060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2270002066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crawler Tractor/Dozers	2270002069	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Skid Steer Loaders	2270002072	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Tractors	2270002075	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Dumpers/Tenders	2270002078	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Other Construction Equipment	2270002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Aerial Lifts	2270003010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Forklifts	2270003020	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45

Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Sweepers/Scrubbers	2270003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other General Industrial Equipment	2270003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Material Handling Equipment	2270003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, AC\Refrigeration	2270003060	0.02	0.10	0.20	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Terminal Tractors	2270003070	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2270004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Snowblowers (Commercial)	2270004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Front Mowers (Commercial)	2270004046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2270004056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2270004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Turf Equipment (Commercial)	2270004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2270004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, 2-Wheel Tractors	2270005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Tractors	2270005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Combines	2270005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Balers	2270005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Mowers	2270005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Sprayers	2270005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Tillers > 6 HP	2270005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Swathers	2270005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Other Agricultural Equipment	2270005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Irrigation Sets	2270005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Generator Sets	2270006005	0.01	0.03	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pumps	2270006010	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Air Compressors	2270006015	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Gas Compressors	2270006020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Welders	2270006025	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pressure Washers	2270006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Hydro-power Units	2270006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Shredders > 6 HP	2270007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2270007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Airport Ground Support Equipment, Airport Ground Support Equipment	2270008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Underground Mining Equipment, Other Underground Mining Equipment	2270009010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Oil Field Equipment	2270010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Outboard	2282005010	16.03	32.70	0.49	0.01	0.25	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Personal Water Craft	2282005015	4.73	13.86	0.18	0.00	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Pleasure Craft, Gasoline 4-Stroke, Inboard/Sterndrive	2282010005	1.95	21.05	1.46	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Pleasure Craft, Diesel, Inboard/Sterndrive	2282020005	0.04	0.18	1.08	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Pleasure Craft, Diesel, Outboard	2282020010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denali	Mobile Sources, Railroad Equipment, Diesel, Railway Maintenance	2285002015	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Denali	Mobile Sources, Railroad Equipment, Gasoline, 4-Stroke, Railway Maintenance	2285004015	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.40	0.47	0.67	0.50	0.50	0.50	0.50
Denali	Mobile Sources, Railroad Equipment, LPG, Railway Maintenance	2285006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Motorcycles: Off-road	2260001010	30.58	30.01	0.09	0.00	1.10	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Snowmobiles	2260001020	1586.83	3799.75	14.57	1.06	36.37	33.46	0.37	0.93	1.00	1.00	1.00	1.00	1.00	1.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, All Terrain Vehicles	2260001030	15.03	15.45	0.04	0.00	0.53	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2260001060	0.21	3.51	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Tampers/Rammers	2260002006	1.66	7.67	0.02	0.00	0.21	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Plate Compactors	2260002009	0.05	0.28	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Paving Equipment	2260002021	0.06	0.34	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2260002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2260002039	3.62	19.50	0.05	0.00	0.54	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2260002054	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Sweepers/Scrubbers	2260003030	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Other General Industrial Equipment	2260003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2260004015	0.30	0.86	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2260004016	0.03	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Residential)	2260004020	3.57	11.11	0.05	0.00	0.28	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Commercial)	2260004021	0.51	2.33	0.01	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2260004025	4.76	14.54	0.07	0.00	0.40	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters	2260004026	0.27	1.28	0.01	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	(Commercial)															
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2260004030	3.59	9.77	0.04	0.00	0.25	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2260004031	0.29	1.44	0.01	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2260004035	3.89	11.30	0.02	0.00	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2260004036	0.57	1.92	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2260004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Agricultural Equipment, Sprayers	2260005035	0.02	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Generator Sets	2260006005	0.20	0.83	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Pumps	2260006010	1.37	5.43	0.03	0.00	0.16	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Air Compressors	2260006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Hydro-power Units	2260006035	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Logging Equipment, Chain Saws > 6 HP	2260007005	1.50	7.51	0.02	0.00	0.21	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Motorcycles: Off-road	2265001010	1.34	12.02	0.16	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, All Terrain Vehicles	2265001030	14.12	112.54	1.33	0.02	0.15	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Golf Carts	2265001050	3.66	93.71	1.11	0.01	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2265001060	0.17	3.99	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Pavers	2265002003	0.15	4.17	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tampers/Rammers	2265002006	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Plate Compactors	2265002009	0.65	10.15	0.10	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rollers	2265002015	0.26	7.36	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Paving Equipment	2265002021	0.89	17.81	0.21	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Surfacing Equipment	2265002024	0.30	6.65	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2265002027	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Trenchers	2265002030	0.57	12.59	0.22	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Bore/Drill Rigs	2265002033	0.43	5.43	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2265002039	0.98	28.78	0.38	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cement and Mortar Mixers	2265002042	1.14	18.56	0.19	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cranes	2265002045	0.04	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2265002054	0.08	1.84	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rough Terrain Forklifts	2265002057	0.05	0.84	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rubber Tire Loaders	2265002060	0.10	1.81	0.13	0.00	0.00	0.00	0.00	0.38	0.42	0.59	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2265002066	0.31	9.60	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Skid Steer Loaders	2265002072	0.22	5.10	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Dumpers/Tenders	2265002078	0.15	2.83	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Other Construction Equipment	2265002081	0.05	0.86	0.06	0.00	0.00	0.00	0.00	0.34	0.42	0.59	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Aerial Lifts	2265003010	0.12	2.31	0.10	0.00	0.00	0.00	0.00	0.35	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Forklifts	2265003020	0.25	5.23	0.36	0.00	0.00	0.00	0.00	0.44	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Sweepers/Scrubbers	2265003030	0.07	1.61	0.05	0.00	0.00	0.00	0.00	0.41	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other General Industrial Equipment	2265003040	0.27	4.11	0.06	0.00	0.00	0.00	0.00	0.45	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Material Handling Equipment	2265003050	0.01	0.16	0.01	0.00	0.00	0.00	0.00	0.36	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, AC\Refrigeration	2265003060	0.03	0.75	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Terminal Tractors	2265003070	0.01	0.25	0.02	0.00	0.00	0.00	0.00	0.39	0.43	0.60	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Residential)	2265004010	24.37	228.46	2.05	0.02	0.13	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Commercial)	2265004011	0.46	5.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2265004015	2.07	19.44	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2265004016	0.25	2.98	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2265004025	0.13	1.25	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2265004026	0.01	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2265004030	0.28	2.39	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2265004031	0.15	3.72	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2265004035	2.19	29.27	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2265004036	0.18	4.96	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Residential)	2265004040	2.63	37.76	0.43	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Commercial)	2265004041	0.02	0.48	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Front Mowers (Commercial)	2265004046	0.02	0.68	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Shredders < 6 HP (Commercial)	2265004051	0.03	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Residential)	2265004055	25.46	503.31	5.87	0.06	0.15	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2265004056	0.20	6.51	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2265004066	0.03	0.81	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2265004071	0.82	20.41	0.25	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Residential)	2265004075	1.80	21.98	0.21	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2265004076	0.07	0.88	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, 2-Wheel Tractors	2265005010	0.01	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Tractors	2265005015	0.01	0.36	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Combines	2265005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Balers	2265005025	0.04	0.34	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Mowers	2265005030	0.01	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Sprayers	2265005035	0.15	2.30	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Tillers > 6 HP	2265005040	0.25	6.41	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Swathers	2265005045	0.05	0.52	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Other Agricultural Equipment	2265005055	0.05	0.94	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Irrigation Sets	2265005060	0.02	0.40	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Generator Sets	2265006005	12.25	248.81	2.74	0.03	0.08	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pumps	2265006010	3.30	50.23	0.75	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Air Compressors	2265006015	1.25	21.92	0.48	0.00	0.02	0.01	0.00	0.48	0.47	0.67	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Welders	2265006025	2.12	55.89	0.91	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pressure Washers	2265006030	6.40	105.46	1.13	0.01	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Hydro-power Units	2265006035	0.19	4.28	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Shredders > 6 HP	2265007010	0.59	16.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2265007015	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Airport Ground Support Equipment, Airport Ground Support Equipment	2265008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Oil Field Equipment	2265010010	0.84	25.36	0.30	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Recreational Equipment, Specialty Vehicles/Carts	2267001060	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Pavers	2267002003	0.01	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Rollers	2267002015	0.01	0.22	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Paving Equipment	2267002021	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Surfacing Equipment	2267002024	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Trenchers	2267002030	0.02	0.44	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Bore/Drill Rigs	2267002033	0.01	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Concrete/Industrial Saws	2267002039	0.01	0.33	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Cranes	2267002045	0.01	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Crushing/Processing Equipment	2267002054	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Rough Terrain Forklifts	2267002057	0.01	0.27	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Rubber Tire Loaders	2267002060	0.03	0.67	0.12	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2267002066	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Skid Steer Loaders	2267002072	0.03	0.59	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, Other Construction Equipment	2267002081	0.01	0.25	0.05	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, LPG, Industrial Equipment, Aerial Lifts	2267003010	0.02	0.39	0.08	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Industrial Equipment, Forklifts	2267003020	1.57	31.45	5.55	0.01	0.05	0.05	0.01	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Industrial Equipment, Sweepers/Scrubbers	2267003030	0.01	0.21	0.03	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Industrial Equipment, Other General Industrial Equipment	2267003040	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Industrial Equipment, Other Material Handling Equipment	2267003050	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Industrial Equipment, Terminal Tractors	2267003070	0.00	0.12	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, LPG, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2267004066	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Agricultural Equipment, Other Agricultural Equipment	2267005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Agricultural Equipment, Irrigation Sets	2267005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Commercial Equipment, Generator Sets	2267006005	0.20	2.98	0.95	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Commercial Equipment, Pumps	2267006010	0.04	0.66	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Commercial Equipment, Air Compressors	2267006015	0.04	0.76	0.20	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, LPG, Commercial Equipment, Welders	2267006025	0.07	1.38	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Commercial Equipment, Pressure Washers	2267006030	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Commercial Equipment, Hydro-power Units	2267006035	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, LPG, Airport Ground Support Equipment, Airport Ground Support Equipment	2267008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Construction and Mining Equipment, Other Construction Equipment	2268002081	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, CNG, Industrial Equipment, Forklifts	2268003020	0.01	2.44	0.43	0.00	0.00	0.00	0.52	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, CNG, Industrial Equipment, Sweepers/Scrubbers	2268003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Industrial Equipment, Other General Industrial Equipment	2268003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Industrial Equipment, AC\Refrigeration	2268003060	0.00	0.04	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Industrial Equipment, Terminal Tractors	2268003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Agricultural Equipment, Other Agricultural Equipment	2268005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FNSB	Mobile Sources, CNG, Agricultural Equipment, Irrigation Sets	2268005060	0.00	0.23	0.04	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Commercial Equipment, Generator Sets	2268006005	0.00	1.11	0.35	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Commercial Equipment, Pumps	2268006010	0.00	0.06	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Commercial Equipment, Air Compressors	2268006015	0.00	0.07	0.02	0.00	0.00	0.00	0.02	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, CNG, Commercial Equipment, Gas Compressors	2268006020	0.00	0.57	0.11	0.00	0.01	0.01	0.79	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, CNG, Commercial Equipment, Hydro-power Units	2268006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, CNG, Industrial Equipment, Other Oil Field Equipment	2268010010	0.00	1.67	0.18	0.00	0.01	0.01	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Recreational Equipment, Specialty Vehicles/Carts	2270001060	0.03	0.11	0.10	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Pavers	2270002003	0.22	1.18	2.62	0.01	0.21	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tampers/Rammers	2270002006	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Plate Compactors	2270002009	0.01	0.06	0.09	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rollers	2270002015	0.60	3.50	6.69	0.02	0.59	0.57	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Scrapers	2270002018	0.43	3.20	7.41	0.02	0.44	0.42	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Paving Equipment	2270002021	0.04	0.23	0.43	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Surfacing Equipment	2270002024	0.02	0.16	0.26	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Signal Boards/Light Plants	2270002027	0.12	0.46	0.84	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Trenchers	2270002030	0.35	2.21	3.32	0.01	0.36	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Bore/Drill Rigs	2270002033	0.35	1.45	4.00	0.01	0.27	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Excavators	2270002036	1.87	9.58	24.81	0.08	1.75	1.70	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Concrete/Industrial Saws	2270002039	0.03	0.17	0.23	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cement and Mortar Mixers	2270002042	0.02	0.07	0.15	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cranes	2270002045	0.49	1.77	7.01	0.02	0.35	0.34	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Graders	2270002048	0.47	2.14	6.26	0.02	0.42	0.40	0.01	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Trucks	2270002051	1.36	7.96	24.16	0.07	1.18	1.14	0.02	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crushing/Processing Equipment	2270002054	0.10	0.43	1.29	0.00	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rough Terrain Forklifts	2270002057	0.91	5.63	8.98	0.03	0.91	0.89	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rubber Tire Loaders	2270002060	2.36	13.53	32.41	0.09	2.16	2.10	0.03	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2270002066	4.71	20.56	21.69	0.05	3.25	3.15	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crawler Tractor/Dozers	2270002069	1.92	11.34	27.66	0.08	1.77	1.71	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Skid Steer Loaders	2270002072	4.39	17.96	14.74	0.04	2.82	2.74	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Tractors	2270002075	0.25	1.66	3.55	0.01	0.22	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Dumpers/Tenders	2270002078	0.01	0.05	0.05	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Other Construction Equipment	2270002081	0.26	1.73	3.47	0.01	0.25	0.24	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Aerial Lifts	2270003010	0.03	0.11	0.10	0.00	0.02	0.02	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Forklifts	2270003020	0.08	0.66	0.96	0.00	0.09	0.09	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Sweepers/Scrubbers	2270003030	0.04	0.16	0.49	0.00	0.03	0.03	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other General Industrial Equipment	2270003040	0.05	0.18	0.58	0.00	0.04	0.04	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Material Handling Equipment	2270003050	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, AC\Refrigeration	2270003060	0.99	5.13	10.55	0.03	0.89	0.86	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Terminal Tractors	2270003070	0.05	0.25	0.61	0.00	0.05	0.04	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2270004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Snowblowers (Commercial)	2270004036	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Front Mowers (Commercial)	2270004046	0.01	0.05	0.09	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2270004056	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2270004066	0.01	0.06	0.13	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Turf Equipment (Commercial)	2270004071	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2270004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, 2-Wheel Tractors	2270005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Tractors	2270005015	2.12	11.16	20.57	0.05	2.00	1.94	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Combines	2270005020	0.19	0.83	2.16	0.00	0.23	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Balers	2270005025	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Mowers	2270005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Sprayers	2270005035	0.02	0.09	0.16	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Tillers > 6 HP	2270005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Swathers	2270005045	0.02	0.09	0.15	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Other Agricultural Equipment	2270005055	0.05	0.23	0.44	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Irrigation Sets	2270005060	0.03	0.11	0.28	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Generator Sets	2270006005	0.72	2.72	5.34	0.01	0.51	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pumps	2270006010	0.16	0.64	1.27	0.00	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Air Compressors	2270006015	0.31	1.35	3.02	0.01	0.26	0.25	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Gas Compressors	2270006020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Welders	2270006025	0.53	2.12	1.58	0.00	0.32	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pressure Washers	2270006030	0.02	0.08	0.18	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Hydro-power Units	2270006035	0.01	0.06	0.13	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Shredders > 6 HP	2270007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2270007015	0.49	2.39	6.53	0.02	0.45	0.43	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Airport Ground Support Equipment, Airport Ground Support Equipment	2270008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Underground Mining Equipment, Other Underground Mining Equipment	2270009010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Oil Field Equipment	2270010010	0.16	0.70	2.56	0.01	0.12	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Outboard	2282005010	9.27	19.23	0.31	0.00	0.14	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Personal Water Craft	2282005015	2.75	8.29	0.11	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Pleasure Craft, Gasoline 4-Stroke, Inboard/Sterndrive	2282010005	1.16	12.18	0.90	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Pleasure Craft, Diesel, Inboard/Sterndrive	2282020005	0.03	0.10	0.62	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Pleasure Craft, Diesel, Outboard	2282020010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FNSB	Mobile Sources, Railroad Equipment, Diesel, Railway Maintenance	2285002015	0.15	0.64	0.81	0.00	0.11	0.10	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Railroad Equipment, Gasoline, 4-Stroke, Railway Maintenance	2285004015	0.06	1.33	0.02	0.00	0.00	0.00	0.00	0.40	0.47	0.67	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, Railroad Equipment, LPG, Railway Maintenance	2285006015	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
FNSB	Mobile Sources, LPG, Construction and Mining Equipment, All	2267002000	0.13	0.47	2.23	0.05	0.10	0.10	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
FNSB	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Total	2270002000	0.37	3.15	6.29	0.38	1.26	1.22	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Motorcycles: Off-road	2260001010	22.99	22.56	0.07	0.00	0.83	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Snowmobiles	2260001020	142.34	340.85	1.31	0.10	3.26	3.00	0.03	0.93	1.00	1.00	1.00	1.00	1.00	1.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, All Terrain Vehicles	2260001030	11.30	11.62	0.03	0.00	0.40	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2260001060	0.16	2.64	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Tampers/Rammers	2260002006	0.11	0.51	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Plate Compactors	2260002009	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Paving Equipment	2260002021	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2260002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2260002039	0.24	1.29	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2260002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Sweepers/Scrubbers	2260003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Other General Industrial Equipment	2260003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2260004015	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2260004016	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Residential)	2260004020	0.35	1.08	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Commercial)	2260004021	0.38	1.75	0.00	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2260004025	0.46	1.41	0.01	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2260004026	0.20	0.96	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2260004030	0.35	0.95	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2260004031	0.21	1.08	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2260004035	0.38	1.09	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2260004036	0.06	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2260004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Agricultural Equipment, Sprayers	2260005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Generator Sets	2260006005	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Pumps	2260006010	0.04	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Air Compressors	2260006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Hydro-power Units	2260006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Logging Equipment, Chain Saws > 6 HP	2260007005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Motorcycles: Off-road	2265001010	1.01	9.04	0.12	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, All Terrain Vehicles	2265001030	10.62	84.62	1.00	0.02	0.11	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Golf Carts	2265001050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2265001060	0.13	3.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Pavers	2265002003	0.01	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tampers/Rammers	2265002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Plate Compactors	2265002009	0.04	0.67	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rollers	2265002015	0.02	0.49	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Paving Equipment	2265002021	0.06	1.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Surfacing Equipment	2265002024	0.02	0.44	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2265002027	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Trenchers	2265002030	0.04	0.83	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Bore/Drill Rigs	2265002033	0.03	0.36	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2265002039	0.06	1.90	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cement and Mortar Mixers	2265002042	0.07	1.22	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cranes	2265002045	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2265002054	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rough Terrain Forklifts	2265002057	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rubber Tire Loaders	2265002060	0.01	0.12	0.01	0.00	0.00	0.00	0.00	0.38	0.42	0.59	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2265002066	0.02	0.63	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Skid Steer Loaders	2265002072	0.01	0.34	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Dumpers/Tenders	2265002078	0.01	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Other Construction Equipment	2265002081	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.34	0.42	0.59	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Aerial Lifts	2265003010	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.35	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Forklifts	2265003020	0.01	0.14	0.01	0.00	0.00	0.00	0.00	0.44	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Sweepers/Scrubbers	2265003030	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.41	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other General Industrial Equipment	2265003040	0.01	0.11	0.00	0.00	0.00	0.00	0.00	0.45	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Material Handling Equipment	2265003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, AC\Refrigeration	2265003060	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Terminal Tractors	2265003070	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.39	0.43	0.60	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Residential)	2265004010	2.36	22.11	0.20	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Commercial)	2265004011	0.34	3.81	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2265004015	0.20	1.88	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2265004016	0.19	2.24	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2265004025	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2265004026	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2265004030	0.03	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2265004031	0.11	2.80	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2265004035	0.21	2.83	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2265004036	0.02	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Residential)	2265004040	0.25	3.65	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Commercial)	2265004041	0.01	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Front Mowers (Commercial)	2265004046	0.02	0.51	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Shredders < 6 HP (Commercial)	2265004051	0.02	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Residential)	2265004055	2.46	48.66	0.57	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2265004056	0.15	4.89	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2265004066	0.02	0.61	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2265004071	0.61	15.34	0.19	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Residential)	2265004075	0.17	2.12	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2265004076	0.05	0.66	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, 2-Wheel Tractors	2265005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Tractors	2265005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Combines	2265005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Balers	2265005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Mowers	2265005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Sprayers	2265005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Tillers > 6 HP	2265005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Swathers	2265005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Other Agricultural Equipment	2265005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Irrigation Sets	2265005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Generator Sets	2265006005	0.34	6.83	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pumps	2265006010	0.09	1.38	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Air Compressors	2265006015	0.03	0.60	0.01	0.00	0.00	0.00	0.00	0.48	0.47	0.67	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Welders	2265006025	0.06	1.54	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pressure Washers	2265006030	0.18	2.90	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Hydro-power Units	2265006035	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Shredders > 6 HP	2265007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2265007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Airport Ground Support Equipment, Airport Ground Support Equipment	2265008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Oil Field Equipment	2265010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Recreational Equipment, Specialty Vehicles/Carts	2267001060	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Pavers	2267002003	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Rollers	2267002015	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Paving Equipment	2267002021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Surfacing Equipment	2267002024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Trenchers	2267002030	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Bore/Drill Rigs	2267002033	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Concrete/Industrial Saws	2267002039	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Cranes	2267002045	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Crushing/Processing Equipment	2267002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Rough Terrain Forklifts	2267002057	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Rubber Tire Loaders	2267002060	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2267002066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Skid Steer Loaders	2267002072	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Construction and Mining Equipment, Other Construction Equipment	2267002081	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Aerial Lifts	2267003010	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Forklifts	2267003020	0.04	0.82	0.14	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Sweepers/Scrubbers	2267003030	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Other General Industrial Equipment	2267003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Other Material Handling Equipment	2267003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Industrial Equipment, Terminal Tractors	2267003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, LPG, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2267004066	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Agricultural Equipment, Other Agricultural Equipment	2267005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Agricultural Equipment, Irrigation Sets	2267005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Generator Sets	2267006005	0.01	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Pumps	2267006010	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Air Compressors	2267006015	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Welders	2267006025	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Pressure Washers	2267006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Commercial Equipment, Hydro-power Units	2267006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, LPG, Airport Ground Support Equipment, Airport Ground Support Equipment	2267008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Construction and Mining Equipment, Other Construction Equipment	2268002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, Forklifts	2268003020	0.00	0.06	0.01	0.00	0.00	0.00	0.01	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, Sweepers/Scrubbers	2268003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, Other General Industrial Equipment	2268003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, AC\Refrigeration	2268003060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, Terminal Tractors	2268003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Agricultural Equipment, Other Agricultural Equipment	2268005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Agricultural Equipment, Irrigation Sets	2268005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Commercial Equipment, Generator Sets	2268006005	0.00	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Commercial Equipment, Pumps	2268006010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Commercial Equipment, Air Compressors	2268006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, CNG, Commercial Equipment, Gas Compressors	2268006020	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, CNG, Commercial Equipment, Hydro-power Units	2268006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, CNG, Industrial Equipment, Other Oil Field Equipment	2268010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Recreational Equipment, Specialty Vehicles/Carts	2270001060	0.02	0.08	0.07	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Pavers	2270002003	0.01	0.08	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tampers/Rammers	2270002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Plate Compactors	2270002009	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rollers	2270002015	0.04	0.23	0.44	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Scrapers	2270002018	0.03	0.21	0.49	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Paving Equipment	2270002021	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Surfacing Equipment	2270002024	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Signal Boards/Light Plants	2270002027	0.01	0.03	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Trenchers	2270002030	0.02	0.15	0.22	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Bore/Drill Rigs	2270002033	0.02	0.10	0.26	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Excavators	2270002036	0.12	0.63	1.63	0.01	0.12	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Concrete/Industrial Saws	2270002039	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cement and Mortar Mixers	2270002042	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cranes	2270002045	0.03	0.12	0.46	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Graders	2270002048	0.03	0.14	0.41	0.00	0.03	0.03	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Trucks	2270002051	0.09	0.52	1.59	0.00	0.08	0.08	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44

SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crushing/Processing Equipment	2270002054	0.01	0.03	0.09	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rough Terrain Forklifts	2270002057	0.06	0.37	0.59	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rubber Tire Loaders	2270002060	0.16	0.89	2.13	0.01	0.14	0.14	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2270002066	0.31	1.35	1.43	0.00	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crawler Tractor/Dozers	2270002069	0.13	0.75	1.82	0.01	0.12	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Skid Steer Loaders	2270002072	0.29	1.18	0.97	0.00	0.19	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Tractors	2270002075	0.02	0.11	0.23	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Dumpers/Tenders	2270002078	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Other Construction Equipment	2270002081	0.02	0.11	0.23	0.00	0.02	0.02	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Aerial Lifts	2270003010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Forklifts	2270003020	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Sweepers/Scrubbers	2270003030	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other General Industrial Equipment	2270003040	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Material Handling Equipment	2270003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, AC\Refrigeration	2270003060	0.07	0.34	0.70	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Terminal Tractors	2270003070	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2270004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Snowblowers (Commercial)	2270004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Front Mowers (Commercial)	2270004046	0.01	0.04	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2270004056	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2270004066	0.01	0.04	0.10	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Turf Equipment (Commercial)	2270004071	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2270004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, 2-Wheel Tractors	2270005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Tractors	2270005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Combines	2270005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Balers	2270005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Mowers	2270005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Sprayers	2270005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Tillers > 6 HP	2270005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Swathers	2270005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Other Agricultural Equipment	2270005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Irrigation Sets	2270005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Generator Sets	2270006005	0.02	0.07	0.15	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pumps	2270006010	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Air Compressors	2270006015	0.01	0.04	0.08	0.00	0.01	0.01	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Gas Compressors	2270006020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Welders	2270006025	0.01	0.06	0.04	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pressure Washers	2270006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Hydro-power Units	2270006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Shredders > 6 HP	2270007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2270007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Airport Ground Support Equipment, Airport Ground Support Equipment	2270008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Underground Mining Equipment, Other Underground Mining Equipment	2270009010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Oil Field Equipment	2270010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Outboard	2282005010	27.65	57.36	0.92	0.01	0.43	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Personal Water Craft	2282005015	8.21	24.73	0.33	0.01	0.15	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Pleasure Craft, Gasoline 4-Stroke, Inboard/Sterndrive	2282010005	3.45	36.31	2.69	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Pleasure Craft, Diesel, Inboard/Sterndrive	2282020005	0.08	0.31	1.84	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Pleasure Craft, Diesel, Outboard	2282020010	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE Fairbanks	Mobile Sources, Railroad Equipment, Diesel, Railway Maintenance	2285002015	0.01	0.04	0.05	0.00	0.01	0.01	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, Railroad Equipment, Gasoline, 4-Stroke, Railway Maintenance	2285004015	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.40	0.47	0.67	0.50	0.50	0.50	0.50
SE Fairbanks	Mobile Sources, Railroad Equipment, LPG, Railway Maintenance	2285006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Motorcycles: Off-road	2260001010	5.92	5.76	0.02	0.00	0.21	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Snowmobiles	2260001020	111.75	267.44	0.96	0.07	2.54	2.34	0.03	0.93	1.00	1.00	1.00	1.00	1.00	1.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, All Terrain Vehicles	2260001030	2.94	2.96	0.01	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2260001060	0.04	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Tampers/Rammers	2260002006	0.22	1.02	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Plate Compactors	2260002009	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Paving Equipment	2260002021	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2260002027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2260002039	0.48	2.58	0.01	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2260002054	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Sweepers/Scrubbers	2260003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Industrial Equipment, Other General Industrial Equipment	2260003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2260004015	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2260004016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Residential)	2260004020	0.30	0.94	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Chain Saws < 6 HP (Commercial)	2260004021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2260004025	0.41	1.23	0.01	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2260004026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2260004030	0.31	0.82	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2260004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2260004035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2260004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2260004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Agricultural Equipment, Sprayers	2260005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Generator Sets	2260006005	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Pumps	2260006010	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Air Compressors	2260006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Commercial Equipment, Hydro-power Units	2260006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 2-Stroke, Logging Equipment, Chain Saws > 6 HP	2260007005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Motorcycles: Off-road	2265001010	0.26	2.31	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, All Terrain Vehicles	2265001030	2.72	21.50	0.26	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Golf Carts	2265001050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Recreational Equipment, Specialty Vehicles/Carts	2265001060	0.04	0.80	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Pavers	2265002003	0.02	0.56	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tampers/Rammers	2265002006	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Plate Compactors	2265002009	0.09	1.35	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rollers	2265002015	0.03	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Paving Equipment	2265002021	0.12	2.38	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Surfacing Equipment	2265002024	0.04	0.88	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Signal Boards/Light Plants	2265002027	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Trenchers	2265002030	0.08	1.68	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Bore/Drill Rigs	2265002033	0.06	0.73	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Concrete/Industrial Saws	2265002039	0.13	3.81	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cement and Mortar Mixers	2265002042	0.15	2.52	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Cranes	2265002045	0.01	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Crushing/Processing Equipment	2265002054	0.01	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rough Terrain Forklifts	2265002057	0.01	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Rubber Tire Loaders	2265002060	0.01	0.25	0.02	0.00	0.00	0.00	0.00	0.38	0.42	0.59	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2265002066	0.04	1.27	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Skid Steer Loaders	2265002072	0.03	0.69	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Dumpers/Tenders	2265002078	0.02	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Construction and Mining Equipment, Other Construction Equipment	2265002081	0.01	0.12	0.01	0.00	0.00	0.00	0.00	0.34	0.42	0.59	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Aerial Lifts	2265003010	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.35	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Forklifts	2265003020	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.44	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Sweepers/Scrubbers	2265003030	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.41	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other General Industrial Equipment	2265003040	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.45	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Material Handling Equipment	2265003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, AC\Refrigeration	2265003060	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Terminal Tractors	2265003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.43	0.60	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Residential)	2265004010	2.06	19.37	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn Mowers (Commercial)	2265004011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Residential)	2265004015	0.19	1.74	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rotary Tillers < 6 HP (Commercial)	2265004016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Residential)	2265004025	0.01	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Trimmers/Edgers/Brush Cutters (Commercial)	2265004026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Residential)	2265004030	0.02	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2265004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Residential)	2265004035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Snowblowers (Commercial)	2265004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Residential)	2265004040	0.23	3.38	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Rear Engine Riding Mowers (Commercial)	2265004041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Front Mowers (Commercial)	2265004046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Shredders < 6 HP (Commercial)	2265004051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Residential)	2265004055	2.27	44.97	0.52	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2265004056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2265004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Turf Equipment (Commercial)	2265004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Residential)	2265004075	0.16	1.99	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2265004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, 2-Wheel Tractors	2265005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Tractors	2265005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Combines	2265005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Balers	2265005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Agricultural Mowers	2265005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Sprayers	2265005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Tillers > 6 HP	2265005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Swathers	2265005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Other Agricultural Equipment	2265005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Agricultural Equipment, Irrigation Sets	2265005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Generator Sets	2265006005	0.13	2.63	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pumps	2265006010	0.03	0.52	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Air Compressors	2265006015	0.01	0.23	0.01	0.00	0.00	0.00	0.00	0.48	0.47	0.67	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Welders	2265006025	0.02	0.58	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Pressure Washers	2265006030	0.07	1.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Commercial Equipment, Hydro-power Units	2265006035	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Shredders > 6 HP	2265007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2265007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Airport Ground Support Equipment, Airport Ground Support Equipment	2265008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Gasoline, 4-Stroke, Industrial Equipment, Other Oil Field Equipment	2265010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Recreational Equipment, Specialty Vehicles/Carts	2267001060	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Pavers	2267002003	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Rollers	2267002015	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Paving Equipment	2267002021	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Surfacing Equipment	2267002024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Trenchers	2267002030	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Bore/Drill Rigs	2267002033	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Concrete/Industrial Saws	2267002039	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Cranes	2267002045	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Crushing/Processing Equipment	2267002054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Rough Terrain Forklifts	2267002057	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Rubber Tire Loaders	2267002060	0.00	0.09	0.02	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2267002066	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Skid Steer Loaders	2267002072	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Construction and Mining Equipment, Other Construction Equipment	2267002081	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Aerial Lifts	2267003010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Forklifts	2267003020	0.01	0.22	0.04	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Sweepers/Scrubbers	2267003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Other General Industrial Equipment	2267003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Other Material Handling Equipment	2267003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Industrial Equipment, Terminal Tractors	2267003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, LPG, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2267004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Agricultural Equipment, Other Agricultural Equipment	2267005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Agricultural Equipment, Irrigation Sets	2267005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Generator Sets	2267006005	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Pumps	2267006010	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Air Compressors	2267006015	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Welders	2267006025	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Pressure Washers	2267006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Commercial Equipment, Hydro-power Units	2267006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, LPG, Airport Ground Support Equipment, Airport Ground Support Equipment	2267008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Construction and Mining Equipment, Other Construction Equipment	2268002081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, Forklifts	2268003020	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, Sweepers/Scrubbers	2268003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, Other General Industrial Equipment	2268003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, AC\Refrigeration	2268003060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, Terminal Tractors	2268003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Agricultural Equipment, Other Agricultural Equipment	2268005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Agricultural Equipment, Irrigation Sets	2268005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Commercial Equipment, Generator Sets	2268006005	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Commercial Equipment, Pumps	2268006010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Commercial Equipment, Air Compressors	2268006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, CNG, Commercial Equipment, Gas Compressors	2268006020	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, CNG, Commercial Equipment, Hydro-power Units	2268006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, CNG, Industrial Equipment, Other Oil Field Equipment	2268010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Recreational Equipment, Specialty Vehicles/Carts	2270001060	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Pavers	2270002003	0.03	0.17	0.38	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tampers/Rammers	2270002006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Plate Compactors	2270002009	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rollers	2270002015	0.09	0.51	0.96	0.00	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Scrapers	2270002018	0.06	0.47	1.08	0.00	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Paving Equipment	2270002021	0.01	0.03	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Surfacing Equipment	2270002024	0.00	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Signal Boards/Light Plants	2270002027	0.02	0.07	0.12	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Trenchers	2270002030	0.05	0.33	0.48	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Bore/Drill Rigs	2270002033	0.06	0.23	0.61	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Excavators	2270002036	0.27	1.37	3.55	0.01	0.25	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Concrete/Industrial Saws	2270002039	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cement and Mortar Mixers	2270002042	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Cranes	2270002045	0.07	0.26	1.03	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Graders	2270002048	0.07	0.31	0.90	0.00	0.06	0.06	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Trucks	2270002051	0.19	1.14	3.43	0.01	0.17	0.16	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crushing/Processing Equipment	2270002054	0.01	0.07	0.19	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rough Terrain Forklifts	2270002057	0.13	0.82	1.29	0.00	0.14	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Rubber Tire Loaders	2270002060	0.35	2.02	4.74	0.01	0.33	0.32	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Tractors/Loaders/Backhoes	2270002066	0.72	3.08	3.22	0.01	0.50	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Crawler Tractor/Dozers	2270002069	0.28	1.65	4.00	0.01	0.26	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Skid Steer Loaders	2270002072	0.69	2.73	2.19	0.01	0.44	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Off-highway Tractors	2270002075	0.04	0.25	0.52	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Dumpers/Tenders	2270002078	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Construction and Mining Equipment, Other Construction Equipment	2270002081	0.04	0.27	0.52	0.00	0.04	0.04	0.00	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Aerial Lifts	2270003010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Forklifts	2270003020	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Sweepers/Scrubbers	2270003030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other General Industrial Equipment	2270003040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Material Handling Equipment	2270003050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, AC\Refrigeration	2270003060	0.06	0.31	0.64	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Terminal Tractors	2270003070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Leafblowers/Vacuums (Commercial)	2270004031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Snowblowers (Commercial)	2270004036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Front Mowers (Commercial)	2270004046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Lawn and Garden Tractors (Commercial)	2270004056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Chippers/Stump Grinders (Commercial)	2270004066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Turf Equipment (Commercial)	2270004071	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Lawn and Garden Equipment, Other Lawn and Garden Equipment (Commercial)	2270004076	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, 2-Wheel Tractors	2270005010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Tractors	2270005015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Combines	2270005020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Balers	2270005025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Agricultural Mowers	2270005030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Sprayers	2270005035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Tillers > 6 HP	2270005040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Swathers	2270005045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Other Agricultural Equipment	2270005055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Agricultural Equipment, Irrigation Sets	2270005060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Generator Sets	2270006005	0.01	0.03	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pumps	2270006010	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Air Compressors	2270006015	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Gas Compressors	2270006020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Welders	2270006025	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Pressure Washers	2270006030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Commercial Equipment, Hydro-power Units	2270006035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Shredders > 6 HP	2270007010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Logging Equipment, Forest Eqp - Feller/Bunch/Skidder	2270007015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Airport Ground Support Equipment, Airport Ground Support Equipment	2270008005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Underground Mining Equipment, Other Underground Mining Equipment	2270009010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Off-highway Vehicle Diesel, Industrial Equipment, Other Oil Field Equipment	2270010010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Outboard	2282005010	171.92	348.26	5.03	0.08	2.72	2.51	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Pleasure Craft, Gasoline 2-Stroke, Personal Water Craft	2282005015	50.66	146.55	1.89	0.03	0.95	0.88	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Pleasure Craft, Gasoline 4-Stroke, Inboard/Sterndrive	2282010005	20.69	225.76	15.29	0.06	0.11	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Pleasure Craft, Diesel, Inboard/Sterndrive	2282020005	0.46	1.94	11.62	0.03	0.23	0.22	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Pleasure Craft, Diesel, Outboard	2282020010	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yukon-Koyukuk	Mobile Sources, Railroad Equipment, Diesel, Railway Maintenance	2285002015	0.01	0.04	0.05	0.00	0.01	0.01	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Railroad Equipment, Gasoline, 4-Stroke, Railway Maintenance	2285004015	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.40	0.47	0.67	0.50	0.50	0.50	0.50
Yukon-Koyukuk	Mobile Sources, Railroad Equipment, LPG, Railway Maintenance	2285006015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Preliminary Summary of Fairbanks Firewood & Pellet Log Emission Measurements

prepared for:

Alaska Department of Environmental Conservation

September 28, 2014

prepared by:

Sierra Research
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and

Dirigo Laboratories
Clackamas, OR

Preliminary Summary of
Fairbanks Firewood & Pellet Log Emission Measurements

- The Borough and State commissioned Dirigo Laboratories to measure PM emission benefits of burning locally produced pellet logs in Fairbanks.
- Fairbanks commissioned tests of (1) dry Fairbanks birch cordwood (20% moisture content), (2) pellet logs (7.5% moisture content), and (3) a 50/50 mix of cordwood and pellet logs in both a U.S. EPA certified stove and an uncertified stove.
- Dirigo followed EPA test procedures and measured PM emissions at both low-medium and high burn rates. Test results at low-medium burn rates (typical in Fairbanks and used to quantify emissions in the SIP inventory) showed the following:
  - Reductions in PM emissions for both the pellet logs and the mix relative to dry cordwood, ranged from 18% - 54%; and
  - 50/50 mix reductions were roughly twice those found for pellet logs, ranging from 40% - 54%.
- DEC commissioned tests of (1) wet Fairbanks birch cordwood (~40% moisture content) and (2) a 50/50 mix of wet cordwood and pellet logs. Test results at low-medium burn rates showed the 50/50 mix produced the following:
  - 64% reduction in PM emissions for both uncertified and certified stoves relative to wet cordwood.
- Because the tests showed variability in the low burn emission rates, additional tests are needed to confirm the results and assess benefits relative to spruce and other sources of cord wood (wet and dry) burned in Fairbanks.
- While the test results are based on limited samples, they indicate substantial emission reduction potential when the pellet logs are burned in combination with cord wood (wet or dry).
- The test results cannot be generalized to other “energy logs” because they are sensitive to the wood composition and moisture content of the product.
- A preliminary estimate of emission reductions that could be achieved through pellet log use was developed based on existing annual production capacity of 3,000 tons that could be expanded to 15,000 tons by 2019.
- A program targeting pellet log/cordwood mix use on unhealthy days (defined as days forecasted above 35 ug/m^3), which averaged 24 days/winter 2010 – 2013 at the State Office Building, was considered based on current and forecasted pellet log production capacity.
- Assuming a 60% compliance rate with such a targeted program by 2019, a 50/50 mix program would produce an additional 21.8% reduction in space heating PM emissions using 3,700 tons per/year, which is well below potential production capacity in 2019.

sierra research

Report No. SR2010-06-01

2010 Fairbanks Home Heating Survey

prepared for:

Alaska Department of Environmental Conservation

June 21, 2010

prepared by:

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2010 FAIRBANKS HOME HEATING SURVEY

prepared for:

Alaska Department of Environmental Conservation

June 21, 2010

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2010 FAIRBANKS HOME HEATING SURVEY

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1. SUMMARY

Under Contract No. 18-5022-10 funded by the Alaska Department of Environmental Conservation (ADEC), Sierra Research, Inc. (Sierra) conducted a telephone-based survey of residential home heating devices and practices within the Fairbanks $PM_{2.5}$ nonattainment area. Sierra coordinated the study and performed validation and analysis of the collected data. Sierra hired Hays Research Group (Hays) to randomly sample households by ZIP code within the nonattainment area, perform the telephone survey, and deliver the detailed, electronically recorded survey data results to Sierra. The telephone survey was conducted between January 22 and February 16, 2010. A total of 300 household responses were targeted. After review of the recorded data, a validated sample of 299 households remained.

Purpose – The primary purpose of this study was to collect up-to-date information on residential heating practices in Fairbanks during the winter season when extremely cold ambient temperatures cause a significant seasonal increase in fuel combustion for residential heating. Sierra and Hays had conducted similar ADEC-sponsored telephone-based home heating surveys in Fairbanks during the 2005-2006 and 2006-2007 winter seasons. The results of those earlier studies suggested that wood burning use had increased measurably since earlier in the decade, which was likely caused by the large run-up in home heating oil prices during that timeframe.*

ADEC funded this latest survey to ascertain whether this trend or level of wood use has continued and to gain information about other heating types and fuels, such as outdoor wood boilers and coal, that were not explicitly identified in the earlier 2006 and 2007 surveys for use in preparing updated emission inventories to support development of the $PM_{2.5}$ State Implementation Plan for Fairbanks.

Survey Content – The survey focused on identifying the types and usage practices of different home heating devices used in residences within the nonattainment area during winter months. It was organized into a hierarchical series of 71 separate questions that respondents were asked to answer based on the types of heating devices available and used within their homes. Key questions included listing the types of devices used in the household (including the specific type of wood-burning device if used), identifying whether multiple devices were used in the household, and estimating the amount of fuel used in each device (e.g., cords of wood or gallons of heating oil) both during winter and on an annual basis.

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* Given the energy needed to heat homes in Fairbanks under extremely cold wintertime temperatures, home heating costs are substantial. Wood-burning devices offer a cheaper alternative to heating oil at current market prices.

The survey also included questions about future home heating practices, such as estimating the heating oil price that would trigger each respondent to stop burning wood and indicating whether respondents planned to change the devices currently being used for home heat some time within the next two years.

For the first time, the survey also asked respondents to estimate the moisture content of their wood and drying or seasoning periods (in months) before wood is burned. As described later in the report, the results of the moisture content estimates are of questionable value because of the small number of responses to that question and the difficultly for most residents to accurately estimate the moisture levels in their wood. (As discussed later in the report, a separate, concurrent study to this effort is being conducted to collect actual wood moisture measurements.)

Study Phases and Issues Encountered – The study consisted of three primary phases as listed and summarized below.

1. *Design* – The design phase included two key elements. First, a methodology based on U.S. Census data was applied to determine how many households to sample within each of the ZIP codes contained in the nonattainment area to produce a representative cross-section of heating practices that vary within the area (for example, to account for the fact that only portions of the area have access to steam-circulated District or ―municipal" heat). Second, the survey structure and questionnaire used in the earlier home heating surveys were re-designed to incorporate several additional questions (e.g., wood moisture content) and ensure these additional questions were asked at logical points during the survey. Sierra and Hays collaborated on this phase.

2. *Survey* – The second phase of the study consisted of performing the actual telephone survey and recording the individual household responses to each question into a series of well-organized electronic data files. Hays performed this phase.

3. *Analysis* – The third and final phase of the effort consisted of first performing a detailed set of data consistency and range checks on the survey response data collected and electronically recorded by Hays, and then analyzing and tabulating the results. Sierra performed this phase.

Two key issues arose during the course of the effort that deserve mention.

First, when performing the field consistency and validation checks on the response data, roughly 100 data records either had inconsistencies between interrelated data responses or were outside reasonable limits. Sierra prepared a detailed list of each of these errors/inconsistencies and transmitted it to Hays. After collective review, it was agreed that most of these errors/inconsistencies could be fairly easily corrected by simply editing specific fields in the response database. For example, in the initial section of the survey where the types of heating devices available in each household are recorded, a wood-burning device may have been recorded with a ―No" value, even though subsequent sections of the survey reflected use of a wood-burning device Hays confirmed that cases like these were clear instances where the response in the initial section was incorrect (as corroborated by the types of data subsequently recorded for that household). In this example, the response in the initial section was simply changed from ―No" to ―Yes."

These types of corrective edits were made only when it was clear what should have been entered into the response database. For those 12 records where the intended responses could not be clearly inferred and corrections could thus not be made, Hays re-sampled ―replacement" households.

Second, under the analysis phase of the effort Sierra also planned to perform a series of comparisons of key device counts and usage rates between the 2006, 2007, and 2010 survey data to look for trends and examine usage variations in the samples. While integrating the similarly validated data from the 2006 and 2007 surveys, it was recalled that the ZIP-code-specific sampling targets (and households sampled) in the 2006 and 2007 survey were developed using a different approach to that taken for the 2010 survey. To ensure proper comparisons across the survey samples, the ZIP-code tabulated results from these earlier surveys were re-weighted to composite totals using the same weightings from the 2010 survey. This was not a trivial effort, but was necessary to ensure the comparisons across survey samples were not biased by differing sampling strategies and thus potentially misleading.

Key Findings - Key results from the 2010 survey included tabulated estimates of the number and types of heating devices used within the PM2.5 nonattainment area, as well as per household usage rates for each type of device based on the survey responses.

Device Counts - First, Table 1-1 summarizes the counts of devices found in the survey sample along with estimates of total heating devices within the entire Fairbanks $PM_{2.5}$ nonattainment area. As shown in the highlighted ―Nonattainment Area" column, woodstoves and central oil furnaces are the most common heating devices, with estimated counts of 7,980 and 21,130, respectively, over the entire nonattainment area. Of the combined total of 8,610 woodstoves and fireplaces with inserts, roughly one-third (2,930) are un-certified (pre-1988) models.

Fireplaces without inserts, estimated at a relatively small population of 540 according to Table 1-1, may nevertheless be significant contributors to the emission inventory from wood-burning devices. This is due to the fact that their heating efficiency is much less than those equipped with inserts or woodstoves.

To simplify interpretation of the table, the estimated numbers of appliances in the non-attainment area and the associated standard errors have been rounded to the nearest 10 units, and the probable range for the number of appliances of each type has been rounded to the nearest 10 or 100 units depending on the size of the category.

The estimates of appliance counts are subject to statistical uncertainty as in any survey. The uncertainty in the estimate depends on the total sample size and the counts observed by appliance type in the category, being relatively larger for the categories with a small number of devices.

Table 1-1 2010 Survey Sampled Heating Devices Counts and Estimated Counts within the Fairbanks $PM_{2.5}$ Nonattainment Area				
	Number of Devices			
Heating Device Type	Survey Sample	**Nonattainment Area**	Standard Error	Probable Range
Wood-Burning Device	108[a]	**9,240**	±870	8,400 - 10,100
Fireplace without insert	6 [a]	**540**	±210	320 - 750
Fireplace with insert	7 [a]	**630**	±230	400 - 860
Woodstove	89 [a]	**7,980**	±810	7,200 - 8,800
Un-Certified Stove/Insert	31 [a]	**2,930**	±480	2,500 - 3,400
Certified Stove/Insert	60 [a]	**5,680**	±650	5,000 - 6,300
Outdoor Wood Boiler	1 [a]	**90**	±90	0 - 180
Central Oil Furnace	247	**21,130**	±920	20,200 - 22,100
Portable Heater	11	**940**	±280	660 - 1,220
Direct Vent Heater	53	**4,530**	±590	3,900 - 5,100
Natural Gas Heating	16	**1,370**	±340	1,000 - 1,700
Coal Heat	4	**340**	±170	170 - 510
District Heat	7	**600**	±220	370 - 820
Other	22	**1,880**	±390	1,500 - 2,300
All Heating Devices	**468**	**40,040**	±1,540	**38,500 - 41,600**

[a] Survey sample counts within the wood-burning sector do not match total due to ―unknown" responses.

For example, smaller size count estimates shown in Table 1-1 for devices such as outdoor wood boilers and coal heating devices, are likely to reflect a higher degree of uncertainty because of the fact that very limited amounts of these devices were found in the 299-household survey sample.

The two rightmost columns in Table 1-1 show these computed statistical uncertainties reflected in the device count estimates for the entire nonattainment area. The uncertainties are quantified using the statistical formula for the standard error of a proportion,* based on the total sample size of 468 appliances and the estimated appliance count expressed as a percent of the total. For example, there are 247 oil furnaces in the survey or 52.8% of the total. The standard error of estimate for this proportion is ±2.3% in a survey of 468 appliances, meaning that the actual percentage of oil furnaces will fall within the range from 50.5% to 55.1% with 68 percent probability (the probability under the normal distribution curve between +1 and -1 standard deviations from the mean). The uncertainty in the proportion of oil furnaces translates into an uncertainty of ±920 units in the estimated population of 21,130 oil furnaces. The probable range is the

* See, for example, Introduction to Probability and Statistics: Principles and Applications for Engineering and The Computing Sciences, Milton, J.S., J.C. Arnold – Third Edition. Irwin McGraw-Hill. Boston, MA. 1995. pp 321-323.

number of oil furnaces likely to exist within the non-attainment area with 68 percent probability. There will be only about 1 chance in 3 that the actual number will fall outside this range – being either less than 20,200 or more than 22,100. The statistical uncertainties were estimated in this manner at the most detailed response level of the survey and then aggregated up to estimate uncertainties in category totals and for the entire appliance population in the non-attainment area.

(As indicated with a footnote in Table 1-1, individual device counts from the survey sample for individual types of wood-burning devices do not sum to the total number of reported wood-burning devices from the survey. This is due to the fact in some instances, although respondents indicated the household had a wood-burning device, they were unsure which type it was or what its certification status was. Section 4 of the report explains how these unknown sub-types were handled.)

(Section 4 of the report includes a more detailed discussion of the statistical uncertainty reflected in the 2010 survey data.)

As explained in greater detail later in the report, the device count estimates in Table 1-1 were developed by extrapolating the number of devices recorded in the 299-household survey sample to the entire nonattainment area based on household counts by ZIP code from the 2000 U.S. Census.

Table 1-2 summarizes the difference between the total number of households in the nonattainment area and the number of sampled households by ZIP code. The ratio between the total and sampled households is shown in the bottom row of Table 1-2. This Extrapolation Factor was used to expand the number of home heating devices counted in the survey sample to the estimates for the entire nonattainment area presented earlier in Table 1-1.

Table 1-2
Comparison of Total Households and Survey-Sampled Households by ZIP Code

Parameter	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Total Households	7,164	1,822	5,329	8,774	2,389	105	25,583
Sampled Households	86	21	61	102	28	1	299
Extrapolation Factor	*83.30*	*86.76*	*87.36*	*86.02*	*85.32*	*105.00*	*85.56*

The differences between the number of households in the survey sample and entire nonattainment area listed in Table 1-2 need to be kept in mind when interpreting average household fuel usage rates and heating costs by device type, which are presented in the following two tables.

Fuel Usage and Heating Costs by Equipped Household – Table 1-3 summarizes average fuel use rates (the amount of fuel per season or year) and heating costs by device type for

Table 1-3
Wood Burning, Heating Oil and Other Fuel Usage Rates and Heating Costs per Equipped Household from the 2010 Survey

Device Type & Fuel	Usage Period	Dntown 99701	Wnwrght[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	All
Stove/Insert Wood Use (cords)	Annual	3.50	3.50	5.23	3.54	3.30	n/a	3.95
	Winter	3.10	3.25	4.71	3.28	2.70	n/a	3.60
Fireplace Wood Use (cords)	Annual	n/a	n/a	6.00	4.00	n/a	n/a	5.20
	Winter	n/a	n/a	5.67	3.00	n/a	n/a	4.60
Central Oil Use (gal)	Annual	1,258	1,083	996	1,141	1,053	n/a	1,135
	Winter	805	875	749	883	781	n/a	818
Portable Heater Fuel Use (gal)	Annual	n/a	n/a	20	2	300	n/a	107
	Winter	n/a	n/a	20	2	300	n/a	107
Direct Vent Heater Fuel Use (gal)	Annual	700	n/a	733	403	417	n/a	493
	Winter	625	n/a	633	311	417	n/a	444
Natural Gas Fuel Cost (dollars)	Annual	$1,950	$900	n/a	$2,717	n/a	No data	$2,159
	Winter	$1,700	$700	n/a	$1,180	n/a	No data	$1,260
District Heat Fuel Cost (dollars)	Annual	$2,800	$2,000	n/a	n/a	n/a	n/a	$2,400
	Winter	$1,500	$1,200	n/a	n/a	n/a	n/a	$1,350

[a] Also includes Birch Hill area
n/a – Not applicable (i.e., indicates where a device was not found in the sample for a specific ZIP code)

households equipped with or using each device/fuel from the survey sample. As reflected in both the individual ZIP codes and the entire sample (shown in the rightmost column labeled ―All"), winter[*] heating device usage rates or costs were an overwhelming portion of annual totals. This is not surprising given the strong seasonal variations in ambient temperature and resultant heating demand experienced in Fairbanks.

As shown in Table 1-3, fuel usage estimates were available for most of the surveyed heating devices: wood-burning devices, central oil furnaces, and portable and direct-vent heaters. Winter fuel usage for the two most common heating devices—central oil furnaces and woodstoves—was 818 gallons of heating oil and 3.60 cords of wood, respectively.

For those heating devices such as natural gas or District heating where the amount of fuel is less well known, the survey respondents were asked to provide usage estimates in the form of heating costs for each device. The seasonal and annual natural gas and District heating costs presented in Table 1-3 represent averages of respondent estimates across those households where each device was used.

[*] In the 2010 survey, winter usage was defined as that from October through March.

Wood-Burning Usage Patterns – On average, Table 1-3 indicates that those households equipped with woodstoves or fireplaces with inserts burned 3.60 cords of wood during the October through March winter months and 3.95 cords annually. Households using fireplaces without inserts (referred to in Table 1-3 and subsequent tables as simply ―fireplaces”) exhibited greater average wood use: 4.60 cords during winter and 5.20 cords over the entire year. Though not shown in Table 1-3, the single household identified in the survey using an outdoor wood boiler indicated that they burned a total of six cords, all during winter.

The higher wood usage for fireplaces without inserts seen in Table 1-3 is consistent with the point raised earlier that they have much lower effective heating efficiency than fireplaces equipped with inserts or woodstoves. More wood must be burned in these ―no-insert” fireplaces to deliver the same amount of effective heat. As it relates to their contribution to emissions inventory, a key question is how are fireplaces without inserts used, as primary or significant heating sources, or more for ambiance/aesthetics and less for heating?

In the 2010 survey sample, a total of six households were found that had no-insert fireplaces as a home heating device. Of these six households, all but one (83%) indicated that they used their fireplaces as a heating source during winter at least 40% of the time. In one household, the no-insert fireplace was the sole heating device; the respondent indicated that a total of eight cords of wood was burned during winter. In addition, all of these six respondents indicated they either cut their own wood, or both buy and cut their wood. This suggests that at least in these households, wood costs may be less of a factor than in other wood-burning households.

Though this is a very limited sample, usage practices of fireplaces without inserts from the 2010 survey suggest they were not simply used as minor heating source or simply for ambiance, but burned large amounts of wood and were used as major, if not primary, household heating sources. By comparison, homes equipped with fireplace inserts or woodstoves used these devices 31% and 50% of the time during winter, respectively, based on respondent estimates from the 2010 survey.

A quick review of households containing fireplaces without inserts from the 2006 and 2007 survey data was performed to see if similar practices were observed in those previous samples. In both of these samples, a different pattern was seen. These samples contained 16 and 20 households, respectively, with ―no-insert” fireplaces. In each sample, only a single household was identified as using its fireplace as a significant heating source (defined as 40% of more) during winter. Thus, the fraction of no-insert fireplaces used as a significant heating source based on these survey samples was 5-6%, much less than found in the 2010 survey. Not coincidentally, wood use in these two households was significant: 3-4 cords during winter. In the remaining ―occasional fireplace use” households from the 2006 and 2007 survey, average household winter wood use was roughly one cord.

This disparity between usage patterns of no-insert fireplace households between the 2010 and earlier survey samples indicates that individual no-insert households exhibit significant wood-burning emissions, although extrapolating these disparate usage patterns to all no-insert households in the nonattainment area reflects a high degree of uncertainty. Usage practices in no-insert households clearly need to be better understood.

(Two cells Table 1-3 are listed as ―No data.” For the one household sampled in this ZIP code, the respondent did not provide natural gas heating cost estimates.)

Fuel Usage and Heating Costs by Any Household – The seasonal and annual usages and heating costs presented earlier in Table 1-3 are not to be confused with averages across all households in the sample, whether or not a household had or used a specific type of heating device. Averages across all households (i.e., any household), which provide a better basis for calculating emission inventories, are displayed in Table 1-4.

Table 1-4
Wood Burning, Heating Oil and Other Fuel Usage Rates and Heating Costs per Household (Any Household) from the 2010 Survey

Device Type & Fuel	Usage Period	Dntown 99701	Wnwrght[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**
Stove/Insert Wood Use (cords)	Annual	0.53	0.83	2.23	1.42	1.30	n/a	**1.27**
	Winter	0.47	0.77	2.01	1.32	1.06	n/a	**1.15**
Fireplace Wood Use (cords)	Annual	n/a	n/a	0.30	0.12	n/a	n/a	**0.10**
	Winter	n/a	n/a	0.28	0.09	n/a	n/a	**0.09**
Central Oil Use (gal)	Annual	1,141	619	833	906	940	n/a	**938**
	Winter	730	500	626	701	697	n/a	**676**
Portable Heater Fuel Use (gal)	Annual	n/a	n/a	0.98	0.08	10.71	n/a	**3.95**
	Winter	n/a	n/a	0.98	0.08	10.71	n/a	**3.95**
Direct Vent Heater Fuel Use (gal)	Annual	90	n/a	84	87	104	n/a	**87**
	Winter	80	n/a	73	67	104	n/a	**79**
Natural Gas Fuel Cost (dollars)	Annual	$113	$171	n/a	$133	n/a	No data	**$116**
	Winter	$99	$133	n/a	$58	n/a	No data	**$67**
District Heat Fuel Cost (dollars)	Annual	$65	$381	n/a	n/a	n/a	n/a	**$56**
	Winter	$35	$229	n/a	n/a	n/a	n/a	**$32**

[a] Also includes Birch Hill area
n/a – Not applicable (i.e., indicates where a device was not found in the sample for a specific ZIP code)

Average device usage rates and heating costs on this any-household basis in Table 1-4 are by definition, lower than corresponding values presented earlier in Table 1-3. This is because the denominator or number of households being averaged in Table 1-4 is always larger, and in many cases significantly larger, than the number of equipped households on which the Table 1-3 averages are based.

The difference between the two sets of averages in Tables 1-3 and 1-4 are perhaps best explained by example. According to Table 1-3, average winter wood use in households equipped with woodstoves or fireplaces with inserts was 3.60 cords. This average represents only those households within the survey with these wood-burning devices. As reported earlier in Table 1-1, the total number of woodstove or fireplace-with-insert households in the survey sample was 96 (7 + 89). The total amount of wood burned across these households is 345.6 cords (96 equipped households × 3.60 cords/household). The total number of households in the survey sample, irrespective of which heating devices they used, was 299. Thus, the average winter woodstove/insert use across all (or any) households in the survey sample is 1.15 cords (345.6 total cords ÷ 299 total households) as reported in Table 1-4.

Although less intuitive, this same averaging approach was applied to the heating cost estimates for natural gas and District heating shown at the bottom of Table 1-4. In these cases, the averages across all households in the survey are much lower than the equipped household averages given in Table 1-3 because these heating devices were less common.

Comparisons Across Surveys – Finally, Table 1-5 presents a comparison of key tabulations from each of the three separate Fairbanks Home Heating surveys: 2006, 2007, and the current 2010 survey. As explained earlier, the tabulations from the earlier surveys were re-weighted by ZIP code using the same weightings on which the 2010 survey was based for consistency when compared with the 2010 results. Highlighted cells in Table 1-5 identify key metrics where significant changes were observed in the 2010 survey compared to the earlier surveys.

First, the overall percentage of wintertime wood-burning device use increased to over 17% in the 2010 sample (over usage fractions of 10-12% in the earlier surveys). In addition, the distribution of wood-burning devices used has changed: no-insert fireplace use is lower in the 2010 sample (5.8%), while woodstove use is higher (86.4%). Within the populations of woodstoves and fireplaces with inserts in the survey samples, the fraction of un-certified stoves/inserts has dropped markedly from 52.4% in 2006 to 34.1% in 2010. On the other hand, winter wood usage (i.e., the amount burned per wood-burning household) has increased noticeably for both stoves/inserts and no-insert fireplaces. (As discussed earlier, the variations observed for the no-insert fireplaces may be related to small sample sizes.)

Beyond the wood-burning sector, Table 1-5 also highlights a clear reduction in the wintertime central oil use. Although the usage fraction for central oil furnaces (the respondent-estimated fraction of use within the household) had remained fairly steady, between 63.9% and 68.0% as reported in the upper section of Table 1-5, usage amounts (gallons of fuel oil) per household dropped nearly 20% in the 2010 sample (818 gallons) compared to the earlier surveys. An analysis of Fairbanks heating degree days[*] during the same six-month winter periods of each survey indicated that ambient temperature-based heating demand in 2010 was roughly 94% of the winter average of 2006 and 2007. Thus, most of the 20% decrease in central oil usage seen in the 2010 survey was not the result of year-to-year ambient temperature variations.

[*] Calculated 65 °F heating degree days at Fairbanks International Airport (PAFA), www.degreedays.net

Table 1-5
Summary of Key Results from 2006, 2007 and 2010 Home Heating Surveys

Statistic	Parameter	Survey Results		
		2006[a]	2007[a]	2010
Average Winter Device Use by Type (% of Household Use)	Wood	**10.1%**	**11.8%**	**17.2%**
	Central Oil	68.0%	63.6%	67.3%
	Portable	0.7%	0.5%	0.2%
	Direct Vent	8.6%	7.4%	8.2%
	Natural Gas	2.6%	2.3%	4.5%
	Coal Heat	n/a	n/a	0.5%
	District Heat	2.8%	1.1%	1.3%
	Other	7.2%	13.4%	0.7%
Wood Burning Type (% of Wood-Burning Devices)	Fireplace	**13.0%**	**17.5%**	**5.8%**
	Fireplace + Insert	8.3%	5.6%	6.8%
	Woodstove	**78.8%**	**76.9%**	**86.4%**
	Wood Boiler	n/a	n/a	1.0%
Wood Stove/Insert Cert Type (% of Woodstoves/Inserts)	<1988 (Un-Certified)	**52.4%**	**46.8%**	**34.1%**
	≥1988 (Certified)	**47.6%**	**53.2%**	**65.9%**
Stove/Insert Wood Use (cords), Winter	Winter Season	**2.87**	**2.85**	**3.60**
Fireplace Wood Use (cords), Winter	Winter Season	**0.76**	**0.74**	**4.60**
Central Oil Use (gallons), Winter	Winter Season	**1,099**	**1,011**	**818**
Portable Heater Fuel Use (gallons), Winter	Winter Season	91.7	152.7	107.3
Direct Vent Heater Fuel Use (gallons), Winter	Winter Season	296	472	444
Natural Gas Heating Fuel Cost (dollars), Winter	Winter Season	**$553**	**$947**	**$1,260**
Municipal Heating Fuel Cost (dollars), Winter	Winter Season	n/a	n/a	$1,350

[a] Winter usage in these surveys encompassed October-May; 2010 winter usage spanned October-March.

A significant increase in wintertime natural gas heating costs per equipped household is also highlighted in Table 1-5. Costs per household have more than doubled from $553 in 2006 to $1,260 in 2010. Whether this reflects a greater usage of natural gas heating is unclear; no analysis of changes in residential natural gas heating prices over this four-year period was performed. However, as also reported in Table 1-5, respondent-estimated usage fraction for natural gas heating increased from 2.6% in 2006 to 4.5% in 2010.

As footnoted in Table 1-5, one element that was not fully consistent across the three surveys was the definition of winter season activity. For the 2006 and 2007 surveys, winter was defined as October through May; as noted earlier, the 2010 survey defined winter as October through March. Rather than try to adjust* the results data from the earlier surveys downward to reflect the shorter winter period in the 2010 survey, this difference is simply noted. Thus, the higher winter season usage seen in the 2010 survey would be further magnified if a seasonal adjustment were made.

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* Given the strong relationship between ambient temperature and residential heating demand/activity, it is not appropriate to simply adjust the 2006 and 2007 usage data by the difference in winter periods across the three surveys (i.e., by a factor of 6/8 months.) because historical April-May ambient temperatures tend to be much warmer than the average from October-March.

2. INTRODUCTION

This introduction provides a review of the background behind the effort, the project objectives, and the organization of the remainder of the report.

2.1 Background

Fairbanks has been collecting measurements of fine particulate ($PM_{2.5}$) concentrations at the State Office Building in the downtown area for over a decade. Those measurements show a distinct seasonal pattern of elevated concentrations during both summer and winter months. Large, uncontrolled wild fires are the principal cause of the elevated summer values. The causes of the elevated winter values are more complex and include severe meteorology (i.e., low wind speed, low mixing depth heights, and arctic winter temperatures) that limit dispersion potential, combustion of fuel for space heating and power production as well as poorly understood atmospheric chemistry that promotes secondary particulate formation. Collectively, these factors have caused the Borough to routinely exceed the more stringent 35 $\mu g/m^3$ National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ that the U.S. Environmental Protection Agency (EPA) established in 2006, and resulted in Fairbanks being designated as a $PM_{2.5}$ nonattainment area in December 2009.

ADEC has sponsored this study to collect information on the types and usage rates of residential heating equipment and fuels in Fairbanks. The specific heating devices/fuels that were surveyed are listed below.

- Wood-burning devices (fireplaces, fireplaces with inserts and woodstoves)
- Central oil furnaces
- Portable fuel oil/kerosene devices
- Direct-vent type heaters such as Toyo or Monitor brands
- Natural gas heating
- Coal heating
- District[*] heating (from circulated steam)

The study method was a telephone-based survey conducted by Hays Research Group (Hays) over a sample of roughly 300 residential households in Fairbanks. The survey

[*] The household survey form and electronic response database use the term ―Municipal Heating" to refer to district heating provided within portions of the Fairbanks area from steam circulated in underground pipes. For this point in the report forward, district and municipal heating refer to this same type of steam heating.

consisted of a total of 71 "tiered" questions organized and asked in a hierarchical structure based on the types of heating devices that each respondent indicated were used within the household. Respondents were generally queried about the types and usage rates (e.g., fuel burned or costs incurred per season or year) for each device/fuel type used. Given the likely significance of the emissions contribution from wood-burning to total $PM_{2.5}$ emissions during cold wintertime conditions, the survey included additional questions related to the types and ages of specific wood-burning devices to aid in quantifying emission estimates for this source sector.

Unlike the earlier 2006 and 2007 surveys, this 2010 survey also included questions on wood drying practices and estimated moisture content. The responses on wood drying practices and estimated moisture content will be used in conjunction with direct measurements of wood usage and moisture content from a subset of the wood-burning households identified in this survey that are being collected under a separate concurrent study being performed by the Cold Climate Housing Research Center (CCHRC). Energy content (and thus emission rates) is known to vary significantly with wood moisture content. Recoverable heat energy per pound from dry wood is about 2.5 times higher than that from wet wood (60% moisture content).[*] There is concern that as wood-burning usage has increased over the last several years in response to higher heating oil prices, dried wood supplies may have become more limited.

As with the earlier surveys, the 2010 survey targeted a total of 300 households. Within this overall target, the sample was stratified by ZIP code based on the number of households within each ZIP code according to 2000 U.S. Census. Table 2-1 shows the households by ZIP code and the resulting sampling targets by ZIP code for the six ZIP code areas contained within the $PM_{2.5}$ nonattainment area.

Table 2-1
Household Survey Sampling Targets by ZIP Code

ZIP Code	Area	Households[a]	Household Fraction (%)	**Sampling Target**
99701	Downtown	7,164	28.0%	84
99703	Wainwright & Birch Hill	1,822	7.1%	21
99705	North Pole	5,329	20.8%	62
99709	Airport	8,774	34.3%	103
99712	Steese	2,389	9.3%	28
99775	University	105	0.4%	1
TOTALS		25,583	100%	**300**

[a] from 2000 U.S. Census

[*] http://www.treesearch.fs.fed.us/pubs/5783

The polled residences were household-weighted across each of the ZIP codes located within the Fairbanks $PM_{2.5}$ nonattainment area. This enabled the resulting sample to be ―self-weighting" across ZIP codes within the area.

Use of this self-weighting sampling strategy was important in proportionately accounting for different heating types available within specific portions of the nonattainment area (e.g., District heating in the Downtown and Wainwright areas). However, the downside of this approach is that ZIP code areas with few households such as University (99775) result in very small sample sizes that tell less about variations in heating devices and equipment within these areas.

To better explore this secondary objective of examining within ZIP area variations, future surveys, if performed, could be designed to oversample these smaller areas.

2.2 Project Objectives

As noted in Section 1, Sierra and Hays had conducted similar ADEC-funded Fairbanks home heating surveys in 2006 and 2007. Results from both those surveys showed a clear and significant increase in wood burning-based heating in recent years resulting from the large run up in home heating oil prices compared to wood burning estimates compiled in earlier emission inventories.* ADEC funded this latest survey (conducted during early 2010) to ascertain whether this trend has continued and to gain information about other heating types and fuels, such as outdoor wood boilers and coal, that were not explicitly identified in the earlier 2006 and 2007 surveys.

The results of this latest 2010 survey are also being used to produce updated winter-season residential space heating emission estimates within emission inventories being developed in support of the Fairbanks $PM_{2.5}$ State Implementation Plan (SIP), which must be completed by December 14, 2012.

The primary objectives of this report are as follows:

- Describe the structure and content of the collected survey data;
- Document techniques used to validate the raw survey data collected by Hays;
- Present detailed tabulations of the validated data; and
- Discuss key findings from the survey.

2.3 Organization of the Report

Beyond this introduction, the remainder of the report is organized as follows: Section 3 describes the structure and content of the survey data as well as the data handling and validation procedures applied by Sierra to the data as-received from Hays; and Section 4

* L. Williams, et al., ―Criteria Pollutant Inventory for Anchorage, Fairbanks, and Juneau in 2002, 2005 and 2018 – Draft Report," prepared by Sierra Research for Alaska Department of Environmental Conservation, July 13, 2007.

describes the analysis performed on the validated survey data and presents results and key findings from analysis of the data. A series of appendices provides a copy of the survey that was used and more detailed information on the survey results.

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3. DATA HANDLING AND VALIDATION

Telephone survey protocols can be designed and implemented in a manner that minimizes errors in recording the responses as they stated on the phone while the survey is conducted. Nevertheless, mistakes in recording responses can arise simply from data entry errors as the person administering the survey tries to both listen and record categorical or numeric responses as quickly as possible.

As a result, in addition to the internal quality assurance procedures employed by Hays, Sierra applied a series of independent checks to the as-received survey data. These quality assurance and data validation checks are described in this section, following a summary of the content and form of the survey data files obtained from Hays.

3.1 Description of As-Received Data

Survey Content – As summarized earlier, the home heating survey consisted of a total of 71 separate questions that were asked of each household in a –tiered” structure. In other words, based on answers to questions about the types of heating devices/fuels asked at the beginning of the survey, additional questions related to each type of device used were then asked. These key –device type” questions encompassed the first eight questions of the survey and simply asked the respondent to reply either –Yes,” –No,” or –Don’t Know” when asked whether any of the following devices were used for household heating:

1. Wood-burning device;
2. Central oil furnace;
3. Portable fuel oil/kerosene heater;
4. Toyo, Monitor, or other type of direct-vent heater;
5. Natural gas heating;
6. Coal heating;
7. Municipal heating; or
8. Other (not listed above).

For these initial questions (Q1-Q8), respondents were specifically asked to identify multiple heating types used within the household from this list, if applicable. In addition, respondents were asked to provide or estimate the size of their homes (in square feet of living space).

Beyond these initial questions about device/fuel types, the survey then branched to specific questions about individual devices within a particular group (e.g., fireplaces, inserts, or woodstoves). It also included questions about usage rates during both winter (October-March) and on an annual basis. Table 3-1 describes the sections of the survey and identifies the range of questions by number for each ―branch" of the survey based on the types of heating devices used in the household that are determined from responses to the initial section of the survey (Q1-Q9). As highlighted in Table 3-1, the initial and end sections of the survey were asked of all respondents. Questions for other sections were heating type-specific and asked only when those devices were used in each household.

Table 3-1
Layout of 2010 Home Heating Survey

Section No.	Section Name	Question Range
0	**Initial Section – Heating devices used and percentages of heat supplied by device, asked of all respondents**	**Q1-Q9**
1	**Woodstove/Fireplace Insert** – asked only if respondent uses woodstove or fireplace with insert	Q10-Q23
2	**Wood-Burning Fireplace** – asked only if respondent uses fireplace without an insert	Q24-Q31
3	**Outdoor Wood Boiler** – asked only if respondent uses outdoor wood boiler	Q32-Q40
4	**Central Oil** – asked only if respondent uses a central oil furnace	Q41-Q44
5	**Portable/Kerosene Heater** – asked only if respondent uses portable fuel oil or kerosene heating device	Q45-Q50
6	**Direct-Vent Heater** – asked only if respondent uses Toyo, Monitor or other type of direct-vent heater	Q51-Q54
7	**Natural Gas Heating** – asked only if respondent uses natural gas heating device	Q55-Q56
X	**Coal Heating** – asked only if respondent uses coal-fired heating device	Q57-Q60
F	**Municipal Heating** – asked only if respondent uses steam heat from underground piping supplied by the municipality or military	Q61-Q62
End	**Future Section – questions pertaining to planned/future heating practices, asked of all respondents**	**Q63-Q71**

The usage questions were of two types. First, in the initial section of the survey when respondents were asked to identify the types of heating devices used in their household, they were then asked to estimate the percentage of heating supplied by each device used during the October-March winter months. Second, within each device-specific section, respondents were also asked to estimate both winter season and annual usage rates in units specific to each device (e.g., cords of wood for wood-burning, gallons of fuel oil for central oil furnaces, etc.).

For respondents using a wood-burning device, the survey further included questions about the source of wood (purchased or cut by themselves), whether the wood is seasoned for a period before being burned, and the estimated moisture content of the wood.

At the end of the survey, respondents were also asked a series of questions about changes they planned to make in the mix or types of home heating devices currently being used. Within this final section of the survey, wood-burning households were also asked whether they burned more wood this winter than last and to estimate the reduced fuel oil price that would cause them to shift from wood use to heating oil.

Appendix A presents the complete 2010 questionnaire/script used by Hays personnel to conduct the telephone-based surveys. It also identifies the individual branching sections that were used as each household was surveyed and asked detailed follow-up questions that pertained only to the heating types used in that household. This dynamic branching approach minimized the time needed to survey each household and avoided needlessly leading respondents through a series of questions that were not applicable to their specific heating types.

As-Received Data – The primary telephone survey data collected by Hays were provided to Sierra in Excel spreadsheet format. In addition, secondary data collected from the survey were provided in a series of Rich Text Format (RTF) files. These secondary data files include several elements of the survey results that couldn't be fit easily into the structure of the primary spreadsheet. Examples of these secondary data included short phrase descriptions of heating devices categorized as ―Other" that were not represented in the specific devices queried; or responses to Question 57 about annual coal usage, which allowed the respondent to provide usage estimates in either of two different units, tons or bags. Information in these secondary RTF files was also loaded into the analysis spreadsheet in a separate data sheet from the primary data. The columns of the primary data sheet were organized by each survey question, along with date, phone number and zip code. Each row in the primary sheet represented collected data from a specific household.

The initial as-received survey spreadsheet provided from Hays contained responses for a total of 300 randomly selected households, sample-weighted by ZIP code as explained earlier in Section 2.1.

Sierra loaded the primary response and supplemental data provided by Hays into an analysis spreadsheet called ***FNSB_2010_Survey_Tabulations.xls*** provided as a separate electronic deliverable under this effort. The as-received primary data were loaded into this workbook in a sheet named *RawData*. The secondary responses tables from the RTF files were loaded into separate areas in a sheet named *SupplementalData* within this analysis spreadsheet.

3.2 Quality Assurance and Validation Procedures

Once the survey data files were transmitted from Hays to Sierra, a series of data handling, quality assurance checks, and validation procedures were applied to the as-received data. These data validation checks are described in this sub-section.

Numeric Data Conversions - All the numeric responses in the spreadsheet provided by Hays were stored as text strings rather than as numbers; mathematical tabulations or range check operations could not be properly performed on these values as text. So the first step applied by Sierra to the as-received data consisted of converting these text values to numbers. (The Excel VALUE function was used to perform these text-to-numeric conversions.) The converted data were stored in a separate sheet in the analysis workbook called *ClnData* upon which a series of data validation and consistency checks were then applied.

Field Consistency Checks – As noted earlier, the telephone surveys were conducted in a branching manner whereby once each respondent's heating devices were identified, additional follow-up questions were asked about each device used in the household. As a result, specific fields in the survey database should exhibit relational dependencies. When expected relational dependencies for specific fields within a household data record were not found, an error was flagged.

For example, if a respondent indicated use of a wood-burning device (Q1=1 for ―Yes”), the data field for Questions 1a (Q1a) should have a value ranging from 1 to 5 to represent one of the following types of wood-burning devices:

1. Fireplace (no insert);
2. Fireplace with insert;
3. Wood-burning stove;
4. Outdoor wood boiler; or
5. Don't know or refused to respond.

A field consistency check was applied for the responses in the Q1 and Q1a fields to ensure that if Q1 (Do you use a wood-burning device?) was 1 or ―Yes” that the Q1a values had to range from 1 through 5. If a blank entry was found in Q1a when Q1 was 1, or conversely if Q1a had values from 1 through 5 and Q1 was 2 (No) or 3 (Don't Know/Refused to Respond), a consistency error was flagged for that household record in the survey database.

Because the survey questions were designed and asked in a branching, hierarchical manner, there were a large number of fields in the response database for which relational rules existed and field consistency checks were applied. Roughly 20 separate sets of related field consistency checks were applied to the survey response data records. These consistency checks were useful for ensuring that consistent data entries were made for each household survey record.

Data Validation Procedures – In addition to the related field consistency checks, a series of data range checks were applied to specific numeric fields such as fuel usage fields. These range checks were applied to reduce the likelihood that data entry errors (e.g. where an extra zero was added) produced outlier values that affected statistical tabulations of the data. Examples of data fields where range check validations were applied are summarized below.

- *Q16) How many months do you season your wood before burning it* – Values of 60 or greater (5 years) ending in zero were assumed to be entry errors where a zero was inadvertently added in entering the response. (One instance of this error was found where an entry of 120 was corrected to 12.)

- *Q18) Amount of wood burned annually with stoves/inserts (in cords)* – Values of 10 cords or more were checked against the wood-burning device type listed in Q1a and the wood-burning heating fraction given in Q9a. These values were only considered valid if used in outdoor wood boilers or if home heating was at least 80% supplied by wood-burning.

- *Q19) Amount of wood burning from October to March with stoves/inserts (in cords)* – The same 10 cord upper limit as in Q18 was applied to the Q19 entries. In addition, the values in Q18 (annual usage) and Q19 (winter usage) were compared. If the winter value was greater than the annual value, they were generally corrected by switching the entries for the two fields. (In one instance, an annual value of 3 and a winter value of 24 were entered. In conjunction with the fact that the wood heating fraction for this household was 60%, the winter value for this household was corrected to 2.)

- *Q20 and Q21) Amount of 40 lb wood pellet bags used annually and during winter with stoves/inserts, respectively* – Similar to the validation checks for Q18 and Q19, annual and winter pellet bag values were compared to each other. Where annual values were lower than winter, the original entries were switched between the two fields.

- *Q41 and Q42) Amount of central heating fuel oil used(in gallons) annually and during winter, respectively* – Similar limits and cross-checks to wood usage responses were also applied for entries of annual and winter central heating oil usage. An upper limit of 7,000 gallons was used to flag both annual and winter usage entries (which would represent an annual heating oil cost of $20,000 or more). For records with flagged entries, annual and winter usage values were compared to each other and to respondent estimates of annual heating oil cost and fractional heating usage within the household from a central oil furnace. In specific cases, it was apparent that either the annual and winter usage entries had been transposed or an extra zero had been added to an entry (e.g., 9,000 instead of 900).

These range validation checks were applied to both the primary data in the *ClnData* sheet as well as the secondary data in the *SupplementalData* sheet in the analysis spreadsheet.

In addition to these range validation checks, entries of “9999” used by Hays to represent missing or unknown values in numeric fields were corrected to blank or null values within the *ClnData* sheet in the analysis spreadsheet to prevent improper tabulation of maxima or means. (In Excel, a value of 9999 would be treated as an actual number, rather than a missing value that should not contribute to an average value across a group of observations. By setting the values for these entries to blank or null values, they are not used by Excel to compute an average across a range of cells.)

3.3 Issues Identified and Corrected

A number of data errors or inconsistencies were identified when the data validation and consistency checks described in Section 3.2 were applied to responses entered for each of the 300 surveyed households. These errors and issues and the corrective actions taken to address them are discussed in this sub-section.

Field Consistency Issues – A number of inconsistent responses were found, particularly in the fields related to heating devices used (Q1-Q8) and percentages of heat supplied by each device (Q9a-Q9h). The particular types of inconsistency issues identified are delineated below with their corrections.

- *Bad “Other” Data Entered* – One respondent entered “1” in Q8 asking about use of other heating devices that are not listed in Q1-Q7, then the type of other device in the secondary data table for this respondent was listed as “None.” The Q8 response (any other devices used) should have been “2” and was corrected.

- *Device Type Wrongly Entered in Other* – In some instances, “other” heating devices used entered as a “1” in Q8 were already entered in the responses to Q1-Q7. For example, the other device listed in the Q8 response was a woodstove, even though Q1 (Do you use a wood-burning device) was entered as “2” (No). A total of four of these types of records were found. The problem with them is that the proper branching in the remainder of the survey was not conducted. With the woodstove example, no follow-up questions in the woodstove section of the survey (Section 1, Q10-Q23) were asked. Thus, these records were incomplete and were deleted from the valid response database.

- *Inconsistent Allocations* – In some records, the heating devices used in the household (identified with entries of “1” in Q1-Q8) did not match with a corresponding non-zero heating device usage percentage entered in Q9a-Q9h. For example, a wood-burning device was listed as used 50% of the time in Q9a, but the response to Q1 (Do you use a wood-burning device) was entered as “2” (No). A total of 19 household records were flagged based on inconsistent allocations. Of these 19 records, Hays confirmed that the inconsistencies in 11 of the records could be corrected by editing the percentage entries (from 0% to 100% or vice versa) in the Q9a-Q9h fields or the “1” or “2” usage entries in the

Q1-Q8 fields based on which branches or sections of the survey record had completed information. Sierra performed these corrections and documented the edits within the appropriate cells within the *ClnData* sheet in the analysis spreadsheet. The remaining 8 records were discarded.

- *Potentially Unreported Allocations* – Occasionally the respondent identified multiple heating devices used in Q1-Q8, but each of those devices was not assigned a non-zero usage percentage in the Q9a-Q9h fields, even though the Q9a-Q9h allocations added to 100%. A total of four households were found to exhibit these unreported allocations. At Sierra's request, Hays contacted these households and confirmed in all four cases that the unreported allocations occurred because each household had more heating devices than were actually used. For example, a household had a fireplace, a central oil furnace, and a direct-vent heater, but only used the fireplace and furnace. Thus, these records were confirmed to be valid as recorded.

- *Faulty Entries* – Questions 37 and 38 were supposed to be asked only if the respondent used an outdoor wood boiler. However, a total of 103 household records in the as-received database were found to contain non-blank entries in these fields when no outdoor wood boilers were listed as being used. Follow-up with Hays indicated that the programmed phone survey logic (which guided the surveyors through the device-specific section questions once the usage types were identified in the initial section) was faulty. Hays confirmed that these entries were errors resulting from the faulty logic and that the values in the Q37 and Q38 fields for those records should be deleted. Sierra edited the cells in these affected records to properly contain blank or null values.

Because of these consistency issues, a total of 12 household records from the as-received database were invalidated and removed from the survey sample. Hays was notified about these deleted records and re-sampled a replacement set of 12 new randomly selected households within the same ZIP codes as the original household records that were deleted. After this re-sampling, Sierra identified one other household record with likely errors that was discarded. Because of the timing, Hays was not asked to re-sample for this single additional discarded record.

Also after the re-sampling, 11 other household records were found with missing usage data (i.e., device-specific sections of the survey that should have been asked, but weren't). The reason they weren't discovered during the initial validation checks was that there were no field inconsistencies between the device types in the Q1-Q8 entries and the device usage percentages entered in Q9a-9h. Rather than eliminate these additional 11 records (and affecting the self-weighting nature of the ZIP code-stratified sample), their valid data for the Q1-Q8 and Q9a-Q9h fields were retained and their-specific usages were simply treated as missing.

Thus, the final household survey database consisted of a total of 299 household records.

Unreasonable Value Corrections – In addition to the errors/issues listed above, some of the survey responses for the usage values (e.g., amount of wood burned or heating oil used) were determined to be unreasonable based on the valid range checks and examination of other usage fields as summarized earlier in Section 3.2. As noted in Section 3.2 under ―Data Validation Procedures," the unreasonable values could generally be corrected by examination of other related fields, or removal of a presumed extra trailing zero in these numeric usage fields. Within the ClnData sheet of the analysis spreadsheet, cells where these corrective edits were applied are marked with an Excel ―pop-up" comment which identified the original and corrected value and included an explanation of the correction.

A total of 421 cell corrections were applied, although roughly 95% of these cell corrections were simply editing the Hays ―9999" missing values to null values to ensure the Excel statistical tabulations were not improperly affected by missing data. Not counting these missing value edits, 16 of the 299 household survey records (5%) contained values that were identified as erroneous and corrected. Within the *ClnData* sheet, these are identified with tan/orange cell shading and a pop-up comment indicating what the original value was and why it was changed.

The resulting replacement records and cell corrections were reflected in the *ClnData* sheet in the analysis spreadsheet. These records represented the validated household survey data from which statistical tabulations were developed and described in the following section of the report.

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4. SURVEY ANALYSIS

Once the household survey response data had been checked for consistency and data values were validated, the final phase of the effort consisted of developing a detailed set of tabulations from the valid data and organizing the results into a series of understandable summaries that can ultimately be used to further update the space heating emission sector of the Fairbanks emissions inventory. These study elements are discussed in this section.

4.1 Development of Tabulations

Construction of Pivot Tables – Within the analysis spreadsheet accompanying this report, a series of detailed Excel ―pivot tables" were constructed to produce cross-tabulations of the responses to each question in the home heating survey. (In Excel, pivot tables provide an efficient way to produce multi-tiered cross tabulations of detailed data.) The pivot tables were created in a consistent manner or layout as illustrated below in Figure 4-1, which shows a two-way tabulation of the responses to Question 1 of the survey (Does the household use a wood-burning device).

Figure 4-1
Pivot Cross-Tabulation of Q1 Responses

Q1 Heating Type - Wood Burning (1-Yes, 2-No, 3-DK)

Count	rzip						
q1	99701	99703	99705	99709	99712	99775	Grand Total
1	15	6	29	47	11		108
2	71	15	32	55	17	1	191
3							
Grand Total	86	21	61	102	28	1	299

The pivot table columns shown in Figure 4-1 contain record counts (i.e., household) by ZIP code and a total across all ZIP codes. The areas corresponding to each of the ZIP codes are Downtown Fairbanks (99701), Wainwright (99703), North Pole (99705), Airport (99709), Steese (99712), and University (99775). The pivot table rows stratify the record counts by the individual categorical responses recorded and include a total at the bottom. A ―key" at the top of the pivot table explains what each coded response means. As shown in this key, survey questions for which possible responses were either

―Yes,” ―No,” or ―DK” (Don’t Know) were coded with values of 1, 2, or 3, respectively. (As expected for the validated dataset, responses to this question were either 1 or 2.)

For other questions where there were more than three allowed responses, such as Q1a (type of wood-burning device), the pivot tables contained the appropriate number of rows for the allowed responses. In a number of pivot tables, a ―blank” response row is also included. This applies to questions that were asked only of a subset of the entire 299-respondent sample because of the branching nature of the survey. This is illustrated below in Figure 4-2, which presents the tabulated responses for the different types of wood-burning devices used (Q1a). It shows a total of 195 ―blank” records across all ZIP codes, reflecting the fact that 195 out of 299 households do <u>not</u> use a wood-burning device.

Figure 4-2
Pivot Cross-Tabulation of Q1a Responses

Q1A Wood Burning Type
(1-Fireplace, 2-FP w/insert, 3-Stove, 4-Outdoor Boiler, 5-DK, blank-not applicable)

Count	rzip						
q1a	99701	99703	99705	99709	99712	99775	Grand Total
1			3	3			6
2	1	1	1	3	1		7
3	12	4	25	38	10		89
4				1			1
5				1			1
	73	16	32	56	17	1	195
Grand Total	86	21	61	102	28	1	299

Appendix B contains the entire set of cross-tabulations of valid responses to each of the 71 questions in the 2010 survey. Within these tabulations presented in Appendix B, three tables are highlighted with shading. These tables were not pivot tables themselves but were calculated from results in other pivot tables in order to account for multiple heating devices being used within a single household. This element is described in more detail below.

<u>Normalization to Account for Multiple Use Types</u> – The next step in the analysis consisted of translating the cross-tabulated record counts into fractional or percentage distributions by device or fuel type so the survey results could be applied to update the emissions inventory. For example, a total of 103 out of 299 households were found to have some type of wood-burning device (with woodstoves the clear majority) across all ZIP codes, as shown above in Figure 4-2. This translates to 34.4% of surveyed households that burn wood.

As described earlier, the initial section of the survey asked respondents to identify <u>all</u> of the specific type(s) of heating devices used in the household. Thus the survey accounted for use of multiple heating devices within each household. These instances of multiple device use within a household had to be properly accounted for in tabulating the results to ensure that surveyed usage is correctly extrapolated to the entire population of Fairbanks households.

Table 4-1 shows the multiple device usage factors that were calculated from the validated survey data.. In the first two rows of the table, the sample size is listed (presented both as household counts and percentages of all sampled households). The third row, labeled ―Multi Type Household Factor," represents the ratio of the total number of devices used divided by the number of households. (For example, a factor of 2.0 would indicate an average of two devices in each household.) As seen in Table 4-1 (with the exception of the single household sample in the University area), there is a fairly consistent multi-type factor across all ZIP codes, with an average for the entire sample of 1.57. The last row in Table 4-1 shows the percentages of households by ZIP code that have more than one heating device. As shown, over 38% of all surveyed households use multiple heating devices.

Table 4-1
Sample Size and Multiple Use Types

	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	All
Survey Sample	86	21	61	102	28	1	299
	28.8%	7.0%	20.4%	34.1%	9.4%	0.3%	100.0%
Multi-Type Household Factor	1.40	1.62	1.59	1.68	1.61	1.00	1.57
Multi-Type Household Use %	22.1%	42.9%	44.3%	48.0%	39.0%	0.0%	38.5%

[a] Also includes Birch Hill area

As noted earlier in Section 3.3, 11 household records that were not re-sampled were found with missing usage data, meaning that sections of the survey questions that should have been asked based on devices identified at the start of the survey were not. These records were preserved in the validated database to reflect the valid mix of devices used within each household. However, the remaining data in the device-specific sections of the survey database had to be treated as missing. This necessitated the tabulation of multiple-use household factors and use of these factors to properly normalize the data.

4.2 Survey Results

Device Counts and Usage Distributions – Table 4-2 summarizes the counts (number of households) of heating devices by device type and ZIP code from the survey sample. As seen in Table 4-2, central oil furnaces (247 total households) and wood-burning devices (108 total households) were the most commonly found home heating devices in the 299 household survey sample. The totals of all devices reported at the bottom of Table 4-2 reflect the fact that many households use more than one type of home heating device. These totaled counts, when divided by the number of households surveyed listed earlier in Table 4-1, match the Multi-Type Household Factors also reported in Table 4-1 (for example, within the Downtown area, 120 ÷ 86 = 1.42).

Table 4-2
Counts of Heating Device Types (Number of Surveyed Households with Device)

Heating Device Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Wood Burning	15	6	29	47	11	0	**108**
Central Oil Furnace	78	12	51	81	25	0	**247**
Portable Heat Device	2	1	3	4	1	0	**11**
Direct Vent Type	11	6	7	22	7	0	**53**
Natural Gas	5	4	1	5	0	1	**16**
Coal Heating	1	0	1	2	0	0	**4**
District Heating	2	4	1	0	0	0	**7**
Other	6	1	4	10	1	0	**22**
TOTALS	**120**	**34**	**97**	**171**	**45**	**1**	**468**

[a] Also includes Birch Hill area

Table 4-3 presents the distributions of device usage percentages by ZIP code during the winter months (October-March). These usage percentages were determined from the survey responses to Q9a-Q9h where the respondents are asked to estimate the percentage of time each household device is used during winter. The usage percentages in Table 4-3 are not based on either the counts of household devices or the amounts of fuel used queried in later sections of the survey. The usage percentages have been properly normalized to account for multiple device use within a household as described in the preceding sub-section. As shown in Table 4-3, central oil furnaces are used between 44% and 81% of the time in all ZIP code areas except University, with an average across the entire sample of 67.3%. Wood-burning devices represent 17.2% of total wintertime device usage across the entire sample, with higher percentages in the outlying areas (North Pole, Airport and Steese) than in those nearer the city center (Downtown, Wainwright and University). As seen in Table 4-3, households in the Wainwright/Birch Hill area have a much greater usage of District heating because of access to this underground infrastructure.

Table 4-3 Distributions of Respondent-Estimated Winter Heating Usage Percentages by Device Type							
Heating Device Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Wood Burning	6.8%	9.8%	28.6%	20.1%	19.5%	0.0%	**17.2%**
Central Oil Furnace	80.8%	44.3%	63.2%	63.2%	69.6%	0.0%	**67.3%**
Portable Heat Device	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	**0.2%**
Direct Vent Type	7.0%	17.4%	3.5%	9.7%	10.5%	0.0%	**8.2%**
Natural Gas	4.7%	14.3%	1.6%	4.4%	0.0%	100.0%	**4.5%**
Coal Heating	0.0%	0.0%	0.1%	1.5%	0.0%	0.0%	**0.5%**
District Heating	0.6%	11.7%	1.6%	0.0%	0.0%	0.0%	**1.3%**
Other	0.1%	0.2%	1.2%	1.1%	0.4%	0.0%	**0.7%**

[a] Also includes Birch Hill area

Wood-Burning Device Breakdowns – As noted earlier, despite the fact that the survey indicates wood-burning devices are used less than 20% of the time, they are likely a significant contributor to wintertime ambient $PM_{2.5}$ levels. Table 4-4 lists the breakdowns in the types of wood-burning devices used within each surveyed ZIP code area. As shown, woodstoves represent an overwhelming majority of wood-burning device usage in Fairbanks. Over 86% of the wood burning according to the entire survey sample occurs using woodstoves. This is not surprising given their heating efficiency and the ability to locate the stove within the interior of a residence.

Table 4-4 Distribution of Wood-Burning Devices (Percent of Households Sampled)							
Wood-Burning Device Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Fireplace	0.0%	0.0%	10.3%	6.7%	0.0%	0.0%	**5.8%**
Fireplace with Insert	7.7%	20.0%	3.4%	6.7%	9.1%	0.0%	**6.8%**
Woodstove	92.3%	80.0%	86.2%	84.4%	90.9%	0.0%	**86.4%**
Outdoor Wood Boiler	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	**1.0%**

[a] Also includes Birch Hill area

As also shown in Table 4-4, fireplaces represent most of the remaining wood-burning usage. Those with inserts constitute 6.8% of the overall sample. Fireplaces without inserts, which are extremely energy inefficient for space heating purposes, represent 5.8% of overall wood use. Outdoor boilers were found only in the Airport area and represent 1.0% of the entire surveyed sample.

Table 4-5 provides a further breakdown of the splits between un-certified and certified fireplace inserts or woodstoves. It shows that un-certified stoves/inserts represent about one-third (34.1%) of the overall sample, although the split varies significantly by ZIP code, possibly the result of small sample sizes for some of the ZIP codes.

Table 4-5
Splits Between Un-Certified and Certified Fireplace Inserts/Woodstoves
(Percent of Households Equipped)

Insert/Woodstove Certification Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Un-Certified (<1988)	16.7%	60.0%	46.2%	34.2%	10.0%	0.0%	**34.1%**
Certified (≥1988)	83.3%	40.0%	53.8%	65.8%	90.0%	0.0%	**65.9%**

[a] Also includes Birch Hill area

These splits were compiled based on the responses to Q10a of the survey: *―Was your woodstove or insert installed before or after 1988?"* Beginning in 1988, the U.S. EPA set mandatory smoke emission limits* for new woodstoves. Smoke emission levels of 1988 and newer stoves meeting these EPA limits are generally 50-80% lower than from older un-certified units, so the split between un-certified and certified stoves has a significant effect on particulate emissions.

Unlike the earlier 2006 and 2007 surveys, the 2010 survey also asked respondents who burn wood to estimate the amount of time they season (dry) their wood before using it, and to the extent possible, to estimate its moisture content. A total of 86 respondents provided estimates of their wood seasoning periods. The average seasoning period from these responses was 14.4 months and ranged from a minimum of zero months to a maximum of 48 months.

A much smaller number of wood-burning respondents, 16 households, provided quantitative estimates of the moisture content of their wood. The average moisture content from these responses was 7.9%. However, the accuracy of this estimate is suspect. First, the survey question did not explain how moisture content is defined, nor did it distinguish between representation on a dry or wet basis. Second, 5 of the 16 households responding with an estimate reported a moisture content of zero percent. Even using the typical practice of defining moisture content on a dry basis, a value of zero percent could be reached only if the wood was completely dried in an oven.

As noted earlier in Section 2, a separate study is concurrently being conducted by the CCHRC from a subset of the households polled in this survey to directly measure and more accurately represent wood moisture content.

* EPA certified woodstove smoke emission limits are 7.5 grams/hour and 4.1 grams/hour for non-catalytic and catalytic devices, respectively (http://www.epa.gov/burnwise/woodstoves.html)

Fuel Usage Rates and Costs - Table 4-6 summarizes average fuel usage rates (i.e., the amount of fuel used per season or year) and heating costs by device type for households equipped with or using each device/fuel. These usages are not to be confused with averages across all households.

Table 4-6
Wood Burning, Heating Oil and Other Fuel Usage Rates and Heating Costs per Equipped Household

Device Type & Fuel	Usage Period	Dntown 99701	Wnwrght[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	**All**
Stove/Insert Wood Use (cords)	Annual	3.50	3.50	5.23	3.54	3.30	n/a	3.95
	Winter	3.10	3.25	4.71	3.28	2.70	n/a	3.60
Fireplace Wood Use (cords)	Annual	n/a	n/a	6.00	4.00	n/a	n/a	5.20
	Winter	n/a	n/a	5.67	3.00	n/a	n/a	4.60
Central Oil Use (gal)	Annual	1,258	1,083	996	1,141	1,053	n/a	1,135
	Winter	805	875	749	883	781	n/a	818
Portable Heater Fuel Use (gal)	Annual	n/a	n/a	20	2	300	n/a	107
	Winter	n/a	n/a	20	2	300	n/a	107
Direct Vent Heater Fuel Use (gal)	Annual	700	n/a	733	403	417	n/a	493
	Winter	625	n/a	633	311	417	n/a	444
Natural Gas Fuel Cost (dollars)	Annual	$1,950	$900	n/a	$2,717	n/a	No data	$2,159
	Winter	$1,700	$700	n/a	$1,180	n/a	No data	$1,260
District Heat Fuel Cost (dollars)	Annual	$2,800	$2,000	n/a	n/a	n/a	n/a	$2,400
	Winter	$1,500	$1,200	n/a	n/a	n/a	n/a	$1,350

[a] Also includes Birch Hill area
n/a – Not applicable (i.e., indicates where a device was not found in the sample for a specific ZIP code)

As shown in Table 4-6, households using either fireplaces with inserts or woodstoves burn an average of just under 4 cords annually and 3.60 cords of wood during winter months (October through March) across the entire survey sample. (These averages were compiled from a sample size of 96 households using fireplaces with inserts or woodstoves, consistent with the counts for responses “2” plus “3” in Figure 4-2.) As also shown in Table 4-6, households burning wood in fireplaces without inserts have higher average usage rates, using 5.20 and 4.60 cords annually and in winter, respectively. This is not surprising given the significantly lower net heating efficiency of standard fireplaces compared to those with inserts or woodstoves.

As reported in Table 4-6, households using central oil furnaces consume an average of 1,135 gallons of heating oil annually and 818 gallons during winter months alone. (These averages are based on a total of 247 central oil furnaces identified in the survey.)

Table 4-6 also lists similarly tabulated average fuel amounts or costs for portable/kerosene heaters, direct vent heaters, natural gas-based heating, and municipal heating. The sample sizes these device-specific averages were tabulated from were generally much smaller than for wood-burning and central heating devices. As such, they should be interpreted with caution.

Appendix C provides a complete list of the normalized survey results, tabulated by ZIP code. As noted above, average usage rates for these normalized tabulations are averaged over only those households equipped with the device for which usage is estimated, rather than all households in the survey sample.

Extrapolation of Survey Sample to Nonattainment Area – An important element of the analysis consisted of extrapolating heating device counts and usage rates from the sample of 299 surveyed households to the entire household population within the Fairbanks $PM_{2.5}$ nonattainment area. The extrapolation was based on the 2000 U.S. Census-based total households by ZIP code within the nonattainment area presented earlier in Table 2-1.

Extrapolation factors or multipliers were calculated from the number of households in an area (either an individual ZIP code or the entire area) from the Census data divided by the surveyed households for the same area. For example, the Downtown ZIP code (99701) area contains 7,164 households as listed earlier in Table 2-1. Since a total of 86 households within that ZIP code were surveyed as reported earlier in Table 4-1, the calculated extrapolation factor is 83.30 (7,164 ÷ 86).

Table 4-7 presents these extrapolated estimates of the number of heating devices by ZIP code area and across the entire Fairbanks $PM_{2.5}$ nonattainment area. The first row in the table lists the extrapolation factors calculated for each area to expand the survey sample to the entire population of households for each area. The remaining rows of the table present estimated counts of the number of devices by device type and ZIP code.

The extrapolation of device counts from the survey sample to total households across the entire nonattainment area was performed two different ways: (1) by individual ZIP code and then summed; and (2) for the entire self-weighted sample. In Table 4-7, these total device counts for the nonattainment area are reported in the two rightmost columns labeled ―ZIP Sum” and ―Extrap,” respectively. As seen in comparing these columns, the counts differ slightly. This is largely due to propagation of round-off error from small sample sizes within each ZIP code when summed across all ZIP code areas reflected in the survey sample. As a result, it is believed that the extrapolated counts using the entire self-weighted sample in the rightmost, shaded column are more accurate and should be used as best estimates of heating device counts within the $PM_{2.5}$ nonattainment area based on the 2010 survey data.

Table 4-7
Extrapolated Survey Heating Device Counts to $PM_{2.5}$ Nonattainment Area

Device Type	Dntown 99701	Wnwrt[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	$PM_{2.5}$ NA Area ZIP Sum	
							ZIP Sum	**Extrap**
Extrapolation Factor	*83.30*	*86.76*	*87.36*	*86.02*	*85.32*	*105.00*	*n/a*	*85.56*
Wood-Burning Device	1,250	521	2,533	4,043	939	0	**9,285**	**9,241**
Fireplace without insert	0	0	262	270	0	0	**532**	**538**
Fireplace with insert	96	104	87	270	85	0	**642**	**628**
Woodstove	1,153	416	2,184	3,414	853	0	**8,021**	**7,985**
Un-Certified Stove/Insert	208	312	1,048	1,260	94	0	**2,923**	**2,934**
Certified Stove/Insert	1,041	208	1,223	2,423	845	0	**5,741**	**5,679**
Outdoor Wood Boiler	0	0	0	90	0	0	**90**	**90**
Central Oil Furnace	6,498	1,041	4,455	6,968	2,133	0	**21,095**	**21,134**
Portable Heater	167	87	262	344	85	0	**945**	**941**
Direct Vent Heater	916	521	612	1,892	597	0	**4,538**	**4,535**
Natural Gas Heating	417	347	87	430	0	105	**1,386**	**1,369**
Coal Heat	83	0	87	172	0	0	**343**	**342**
District Heat	167	347	87	0	0	0	**601**	**599**
Other	500	87	349	860	85	0	**1,882**	**1,882**
All Heating Devices	9,996	2,950	8,474	14,709	3,839	105	**40,074**	**40,043**

[a] Also includes Birch Hill area

On this basis, a total of 9,241 wood-burning devices were estimated to be in use within the nonattainment area. Of these, 7,985 are woodstoves and 628 are fireplaces with inserts. From the combined total of 8,613 stoves/inserts, 2,934 are estimated to be un-certified (pre-1988). Fireplaces without inserts and outdoor wood boilers represent the remaining wood-burning devices; their counts within the nonattainment area are 538 and 90, respectively, as shown in Table 4-7. As explained earlier in Section 1, the precision of device count estimates are not necessarily accurate to the whole integer values listed in Table 4-7. The whole integer values are simply shown in this table to illustrate how they were calculated from the sample-to-nonattainment area extrapolation factors.

Statistical Uncertainty Analysis – In extrapolating devices counted in the 299 household survey sample to the entire nonattainment area, an additional issue that was addressed was the resulting statistical uncertainty. As reported earlier in Figure 4-2 and Table 4-2, only one outdoor wood boiler and four coal heaters were found in the 299 household sample. Thus, an analysis of the uncertainties associated with proportional extrapolation of the household sample to the entire nonattainment area was performed.

The results of this uncertainty analysis are presented in the next three tables. The estimates in these tables quantify the statistical uncertainty associated with extrapolating the device usage distributions in the surveyed sample represented earlier in Tables 4-3 through 4-5 to all the households in the nonattainment area. In each of these tables, the standard error of proportion was used as the measure of statistical uncertainty. It represents the accuracy of each proportional (i.e., usage fraction) estimate in the sample, measured as the standard deviation of that proportion.

First, Table 4-8 presents standard errors of proportion associated with the respondent-estimated usage fractions of each major device type reported earlier in Table 4-3. The first value in each cell is the usage fraction from Table 4-3; the second value represents one standard deviation of this usage fraction. For example, the fraction of wood-burning devices used in winter for the entire sample was 17.2% (as listed earlier in Table 4-3). Assuming device usage is normally distributed, the value of ±2.2% listed in the upper right cell in Table 4-8 means that the actual wood-burning usage fraction lies between 15.0% (17.2 - 2.2) and 19.4% (17.2 + 2.2) with 68% probability.*

Table 4-8
Standard Error of Proportion for
Respondent-Estimated Winter Heating Usage Percentages by Device Type

Heating Device Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Wood Burning	6.8% ±2.7%	9.8% ±6.5%	28.6% ±5.8%	20.1% ±4.0%	19.5% ±7.5%	n/a	**17.2% ±2.2%**
Central Oil Furnace	80.8% ±4.2%	44.3% ±10.8%	63.2% ±6.2%	63.2% ±4.8%	69.6% ±8.7%	n/a	**67.3% ±2.7%**
Portable Heat Device	0.1% ±0.3%	2.4% ±3.3%	n/a	n/a	n/a	n/a	**0.2% ±0.3%**
Direct Vent Type	7.0% ±2.8%	17.4% ±8.3%	3.5% ±2.4%	9.7% ±2.9%	10.5% ±5.8%	n/a	**8.2% ±1.6%**
Natural Gas	4.7% ±2.3%	14.3% ±7.6%	1.6% ±1.6%	4.4% ±2.0%	n/a	Insufficient data	**4.5% ±1.2%**
Coal Heating	n/a	n/a	0.1% ±0.4%	1.5% ±1.2%	n/a	n/a	**0.5% ±0.4%**
District Heating	0.6% ±0.8%	11.7% ±7.0%	1.6% ±1.6%	n/a	n/a	n/a	**1.3% ±0.7%**
Other	0.1% ±0.3%	0.2% ±1.0%	1.2% ±1.4%	1.1% ±1.0%	0.4% ±1.2%	n/a	**0.7% ±0.5%**

[a] Also includes Birch Hill area
n/a – Not available

As expected, the usage fraction estimates within individual ZIP code areas have wider ranges of standard error than the overall estimate across all areas because the standard error estimates are related to sample size. As seen in the rightmost column in Table 4-8,

* 68% probability represents the probability of a normally-distributed sample within one standard deviation of its mean.

the standard errors for heating device usage fraction are less than ±3% across the entire nonattainment area.

Similarly, Tables 4-9 and 4-10 present Standard Error of Proportion estimates for proportional device usage within the wood-burning sector and between un-certified and certified woodstoves/inserts, respectively.

Table 4-9
Standard Error of Proportion for
Distribution of Wood-Burning Devices (Percent of Households Sampled)

Wood-Burning Device Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Fireplace	n/a	n/a	10.3% ±3.9%	6.7% ±2.5%	n/a	n/a	**5.8% ±1.4%**
Fireplace with Insert	7.7% ±2.9%	20.0% ±8.7%	3.4% ±2.3%	6.7% ±2.5%	9.1% ±5.4%	n/a	**6.8% ±1.5%**
Woodstove	92.3% ±2.9%	80.0% ±8.7%	86.2% ±4.4%	84.4% ±3.6%	90.9% ±5.4%	n/a	**86.4% ±2.0%**
Outdoor Wood Boiler	n/a	n/a	n/a	2.2% ±1.5%	n/a	n/a	**1.0% ±0.6%**

[a] Also includes Birch Hill area
n/a – Not available.

Table 4-10
Standard Error of Proportion for
Un-Certified and Certified Stove/Insert Splits (Percent of Households Equipped)

Insert/Woodstove Certification Type	Downtown 99701	Wainwright[a] 99703	North Pole 99705	Airport 99709	Steese 99712	University 99775	**All**
Un-Certified (<1988)	16.7% ±4.0%	60.0% ±10.7%	46.2% ±6.4%	34.2% ±4.7%	10.0% ±5.7%	n/a	**34.1% ±4.2%**
Certified (≥1988)	83.3% ±4.0%	40.0% ±10.7%	53.8% ±6.4%	65.8% ±4.7%	90.0% ±5.7%	n/a	**65.9% ±8.0%**

[a] Also includes Birch Hill area
n/a – Not available.

Translation of Results to All-Household Inventory Basis – Table 4-11 presents estimates of key fuel usage rates on a per-household basis across all households within the nonattainment area, irrespective of whether an individual household uses that fuel.

Table 4-11
Wood Burning, Heating Oil and Other Fuel Usage Rates and Heating Costs per Household (Any Household)

Device Type & Fuel	Usage Period	Dntown 99701	Wnwrght[a] 99703	Nth Pole 99705	Airport 99709	Steese 99712	Univ 99775	All
Stove/Insert Wood Use (cords)	Annual	0.53	0.83	2.23	1.42	1.30	n/a	**1.27**
	Winter	0.47	0.77	2.01	1.32	1.06	n/a	**1.15**
Fireplace Wood Use (cords)	Annual	n/a	n/a	0.30	0.12	n/a	n/a	**0.10**
	Winter	n/a	n/a	0.28	0.09	n/a	n/a	**0.09**
Central Oil Use (gal)	Annual	1,141	619	833	906	940	n/a	**938**
	Winter	730	500	626	701	697	n/a	**676**
Portable Heater Fuel Use (gal)	Annual	n/a	n/a	0.98	0.08	10.71	n/a	**3.95**
	Winter	n/a	n/a	0.98	0.08	10.71	n/a	**3.95**
Direct Vent Heater Fuel Use (gal)	Annual	90	n/a	84	87	104	n/a	**87**
	Winter	80	n/a	73	67	104	n/a	**79**
Natural Gas Fuel Cost (dollars)	Annual	$113	$171	n/a	$133	n/a	No data	**$116**
	Winter	$99	$133	n/a	$58	n/a	No data	**$67**
District Heat Fuel Cost (dollars)	Annual	$65	$381	n/a	n/a	n/a	n/a	**$56**
	Winter	$35	$229	n/a	n/a	n/a	n/a	**$32**

[a] Also includes Birch Hill area
n/a – Not applicable (i.e., indicates where a device was not found in the sample for a specific ZIP code)

The fuel usage rates per equipped household reported earlier in Table 4-6 were converted to this all-household basis in Table 4-11 for easier use in generating emission inventory estimates for residential space heating sources within the nonattainment area. As a result, the fuel usage and cost estimates (on an any-household basis) are significantly lower than those in Table 4-6 based on equipped households. For use in estimating emissions, the fuel usage rates per household (per season or annually) would simply be multiplied by the number of households in a given area (e.g., ZIP code or grid cell) and combined with device/fuel type-specific emission rates.

Comparisons Across Surveys – Finally, Table 4-12 presents a comparison of key tabulations from each of the three separate Fairbanks Home Heating surveys: 2006, 2007, and the current 2010 survey. As explained earlier, the tabulations from the earlier surveys were re-weighted by ZIP code using the same weightings on which the 2010 survey was based for consistency when compared with the 2010 results. Highlighted cells in Table 4-12 identify key metrics where significant changes were observed in the 2010 survey compared to the earlier surveys.

First, the overall percentage of wintertime wood-burning device use increased to over 17% in the 2010 sample (over usage fractions of 10-12% in the earlier surveys). In addition, the distribution of wood-burning devices used has changed: no-insert fireplace use is lower in the 2010 sample (5.8%), while woodstove use is higher (86.4%).

Table 4-12
Summary of Key Results from 2006, 2007 and 2010 Home Heating Surveys

Statistic	Parameter	Survey Results		
		2006[a]	2007 [a]	2010
Average Winter Device Use by Type (% of Household Use)	Wood	**10.1%**	**11.8%**	**17.2%**
	Central Oil	68.0%	63.6%	67.3%
	Portable	0.7%	0.5%	0.2%
	Direct Vent	8.6%	7.4%	8.2%
	Natural Gas	2.6%	2.3%	4.5%
	Coal Heat	n/a	n/a	0.5%
	District Heat	2.8%	1.1%	1.3%
	Other	7.2%	13.4%	0.7%
Wood Burning Type (% of Wood-Burning Devices)	Fireplace	**13.0%**	**17.5%**	**5.8%**
	Fireplace + Insert	8.3%	5.6%	6.8%
	Woodstove	**78.8%**	**76.9%**	**86.4%**
	Wood Boiler	n/a	n/a	1.0%
Wood Stove/Insert Cert Type (% of Woodstoves/Inserts)	<1988 (Un-Certified)	**52.4%**	**46.8%**	**34.1%**
	≥1988 (Certified)	**47.6%**	**53.2%**	**65.9%**
Stove/Insert Wood Use (cords), Winter	Winter Season	**2.87**	**2.85**	**3.60**
Fireplace Wood Use (cords), Winter	Winter Season	**0.76**	**0.74**	**4.60**
Central Oil Use (gallons), Winter	Winter Season	**1,099**	**1,011**	**818**
Portable Heater Fuel Use (gallons), Winter	Winter Season	91.7	152.7	107.3
Direct Vent Heater Fuel Use (gallons), Winter	Winter Season	296	472	444
Natural Gas Heating Fuel Cost (dollars), Winter	Winter Season	**$553**	**$947**	**$1,260**
Municipal Heating Fuel Cost (dollars), Winter	Winter Season	n/a	n/a	$1,350

[a] Winter usage in these surveys encompassed October-May; 2010 winter usage spanned October-March.

Within the populations of woodstoves and fireplaces with inserts in the survey samples, the fraction of un-certified stoves/inserts has dropped markedly from 52.4% in 2006 to 34.1% in 2010. On the other hand, winter wood usage (i.e., the amount burned per wood-burning household) has increased noticeably for both stoves/inserts and no-insert fireplaces. (As discussed earlier, the variations observed for the no-insert fireplaces may be related to small sample sizes.)

Beyond the wood-burning sector, Table 4-12 also highlights a clear reduction in the wintertime central oil use. Although the usage fraction for central oil furnaces (the respondent-estimated fraction of use within the household) had remained fairly steady, between 63.9% and 68.0% as reported in the upper section of Table 4-12, usage amounts (gallons of fuel oil) per household dropped nearly 20% in the 2010 sample (818 gallons) compared to the earlier surveys.

A significant increase in wintertime natural gas heating costs per equipped household is also highlighted in Table 4-12. Costs per household have more than doubled from $553 in 2006 to $1,260 in 2010. Whether this reflects a greater usage of natural gas heating is unclear; no analysis of changes in residential natural gas heating prices over this four-year period was performed. However, as also reported in Table 4-12, respondent-estimated usage fraction for natural gas heating increased from 2.6% in 2006 to 4.5% in 2010.

As footnoted in Table 4-12, one element that was not fully consistent across the three surveys was the definition of winter season activity. For the 2006 and 2007 surveys, winter was defined as October through May; as noted earlier, the 2010 survey defined winter as October through March. Rather than try to adjust* the results data from the earlier surveys downward to reflect the shorter winter period in the 2010 survey, this difference is simply noted. Thus, the higher winter season usage seen in the 2010 survey would be further magnified if a seasonal adjustment were made.

###

* Given the strong relationship between ambient temperature and residential heating demand/activity, it is not appropriate to simply adjust the 2006 and 2007 usage data by the difference in winter periods across the three surveys (i.e., by a factor of 6/8 months.) because historical April-May ambient temperatures tend to be much warmer than the average from October-March.

APPENDIX A

2010 Home Heating Survey Questionnaire

hays research group

Fairbanks Heating Survey
Draft G

Phone # ____________ Survey # ________
Interviewer Name ______________
Date ____________

(Location of Home)

Good evening, I am calling from Hays Research Group; we are conducting a brief survey on behalf of the Fairbanks Northstar Borough (BURR-oh) regarding home space heating options. May I please speak to the person most knowledgeable about the heating devices in your home? **(IF NOT AVAILABLE – When would be the best time to reach him/her? Set a callback and get a name.)**

Q1-Q8) Please tell me which of the following devices provide space heat for your home?

Q1) A wood burning device?

1. Yes
2. No
3. DK/REF

Q2) A central Oil furnace?

1. Yes
2. No
3. DK/REF

Q3) Portable Fuel Oil/Kerosene heating device?

1. Yes
2. No
3. DK/REF

Q4) Toyo (TOY-oh), Monitor or other direct vent type heater?

1. Yes
2. No
3. DK/REF

Q5) Natural Gas Heat?

1. Yes
2. No
3. DK/REF

Q6) Coal Heat

1. Yes
2. No
3. DK/REF

Q7) Municipal Heat?

1. Yes
2. No
3. DK/REF

Q8) Other not listed? ________________

QQ) And can you please tell me how many square feet are in your home, not including any garage space?

1. _____________sq. ft.
2. DK/REF

(At least one of the questions between Q1-Q7 must = 1 yes, otherwise terminate)

(Ask Q1a if Q1=1, otherwise skip to Q9)

Q1a) Is your wood burning device a fireplace, a fireplace with insert, a wood burning stove or outdoor wood boiler?

1-Fireplace
2-Fireplace with insert
3-Wood burning stove
4-Outdoor Wood Boiler (note could called hydronic heater by some)
5-DK/REF

Q9) **(Q9 answers must total 100%)** What percentage of your heating is done by each of the following devices during the winter months, from October to March?

a. Wood Burning Device	%
b. Central Oil furnace	%
c. Portable Fuel Oil/Kerosene	%
d. Direct Vent type	%
e. Natural Gas Heat	%
f. Coal Heat	%
g. Municipal Heat	%
h. Other	%

We'll now get into some usage details of each type of heating.

(Section 1: Wood burning stove/Fireplace insert)

(Ask Q10-Q12 if Q1a = 2) "Fireplace with insert" or 3) "Wood burning stove", otherwise skip to Q13)

Q10a) Was your wood burning stove or insert installed before or after 1988?

1) Before
2) After
3) DK/REF

Q11a) How old is your wood burning stove or insert? Allow multiple responses

1) Less than 1 year
2) 1-5
3) 5-10
4) 10-15
5) 15+ years
6) DK/REF

Q11b) Is your wood stove or insert catalytic or non –catalytic?

1) catalytic
2) non-catalytic
3) DK/REF

Q12) Does your stove or insert burn pellets or cord wood? Allow multiple responses

1)Pellets
2)Cord Wood
3) DK/REF

(Ask Q13-Q14 if Q12=2 "Cord wood", otherwise skip to Q15)

Q13) What best describes your use of wood heat during the winter months, October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q14) Where do you get the wood for your heating? Allow multiple responses

1. Buy wood
2. Cut your own
3. DK/REF

(Ask Q15-Q17a if Q14=2 "Cut your own", otherwise skip to Q18)

Q15) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q16) How many months do you season your wood before burning it?

1._______Months
2. DK/REF=9999

Q17) Do you know what the moisture content of your wood is, and if so, what is it?

1._______Percent
2. DK/REF=9999

(Ask Q18-Q19 if Q12 =2 "Cord wood", otherwise skip to Q20)

18) In cords, how much wood do you burn in your wood burning stove or insert annually? (If the respondent asks, one cord of wood is four feet wide, four feet high, and eight feet long stacked)

1. Wood in cords ______
2. DK/REF=9999

Q19) In cords, how much do you burn from October to March?

1. Wood in cords ______
2. DK/REF=9999

(Ask Q20-Q21 if Q12=1 "pellets", otherwise skip to Q22)

Q20) How many 40 lb bags of pellets do you burn in your wood burning stove or insert annually?

1. 40 lb bags of pellets ________
2. DK/refused=9999

Q21) How many bags do you burn from October to March?

1. 40 lb bags of pellets ________
2. DK/refused=9999

(Ask Q22 if q18 or q19= DK/REF, otherwise skip to Q23)

Q22) How much do you spend per year on wood?

1. $__________
2. DK/refused=9999

(Ask q23 if q20 or q21 = DK/REF, otherwise skip to Q24)

Q23) How much do you spend per year on pellets?

1. $__________
2. DK/refused=9999

(Section 2: Wood burning Fireplace)

(Ask Q24-Q25 if Q1a = 1 "Fireplace", otherwise skip to Q32)

Q24) From this list, what best describes your use of wood heat during the winter months, from October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q25) Where do you get the wood for your heating? (Allow multiple responses)

1. Buy wood
2. Cut your own
3. DK/REF

(Ask Q26-Q31 if Q25=2, otherwise skip to Q32)

Q26) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q27) How many months do you season your wood before burning it?

1. Months ______
2. DK/refused=9999

Q28) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent ______
2. DK/refused=9999

Q29) In cords, how much wood do you burn in your fireplace annually?

1. ________cords
2. DK/refused = 9999

Q30) How much do you burn from October to March?

1. ________cords
2. DK/REF=9999

Q31 How much do you spend per year on wood?

1. $__________
2. DK/REF=9999

(Section 3: Outdoor Wood Boiler)

(Ask Q32-Q33 if section if Q1a = 4 "outdoor wood boiler", otherwise skip to Q34)

Q32) What best describes your use of wood heat during the winter months, from October to March?

a. Day time only	d. Weekend only	g. Not currently using any device
b. Evening only	e. Evening and Weekend only	h. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Q33) Where do you get the wood for your heating? (allow multiple responses)
1. Buy wood
2. Cut your own
3. DK/REF

(Ask Q34-Q36 if Q33=2 "cut your own", otherwise skip to Q37)

Q34) When cutting wood do you get a permit?

1. Yes
2. No
3. DK/REF

Q35) How many months do you season your wood before burning it?

1. Months ______
2. DK/REF=9999

Q36) Do you know what the moisture content of your wood is, and if so, what is it?

1. Percent ______
2. DK/REF=9999

Q37) In cords, how much wood do you burn in your outdoor wood boiler annually?

1. ________cords
2. DK/REF=9999

Q38) How much do you burn from October to March?

1. ________cords
2. REF=9999

(ask Q39 if Q33= 1 "Buy wood", otherwise skip to Q40)

Q39) How much do you spend per year on wood?

1. $__________
2. DK/REF=9999

Q40) What is the brand name of your outdoor wood boiler? (open ended)

(Section 4: Central Oil)

(ask Q41-Q44 of Q2=1 "yes", otherwise skip to Q45)

Q41) How large is your fuel oil tank, in gallons?

1. _______Gallons
2. DK/REF=9999

Q42) In gallons, how much oil do you use annually?

1. _______Gallons
2. DK/REF=9999

Q43) How many gallons do you use during the winter months (October – March)?

1. _______Gallons
2. DK/REF=9999

Q44) How much do you spend per year on fuel oil?

1. $__________
2. 9999=No/DK/REF

(Section 5: Portable Fuel Oil/Kerosene Heating Device)

(Ask Q45-Q46 if Q3=1 "YES", otherwise skip to Q47)

Q45) You mentioned using a Portable Fuel Oil or Kerosene Heating Device, does the device use Fuel Oil?

1. Yes
2. No
3. DK/REF

Q46) Does the device use Kerosene?

1. Yes
2. No
3. DK/REF

(If Q45 OR Q46 = 1 "yes", read Q47-Q48, otherwise skip to Q49)

Q47) In gallons, how much oil/kerosene do you use annually?

1. ________gallons
2. DK/REF=9999

Q48) How many gallons do you use during the winter months (October – March)?

1. ________gallons
2. DK/REF=9999

Q49) How much do you spend per year on oil/kerosene? No/DK/REF=9999

1. $________
2. DK/REF=9999

(Section 5.1
For homes using Central Oil, and/or Portable Fuel Oil/Kerosene Heating Devices, and/or Other devices)

(Ask Q50 if Q2=1 "yes" or Q3=1 "yes" or Q7=1 "yes", otherwise skip to Q51

Q50) From this list please tell me what best describes your use of fuel oil and kerosene burning devices during the winter months, from October to March?

a. Day time only	d. Weekend only	h. Not currently using any device
b. Evening only	e. Evening and Weekend only	j. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Section 6: Toyo, Monitor, or other Direct Vent Type of Heater if uses fuel oil and direct vent fuel consumption question

(Ask this section if Q4=1 "yes", otherwise skip to Q55)

If Q2=1 and Q4=1 skip Q 51 & Q52

Q51) In gallons, how much oil do you use annually?

1. _______Gallons
2. 9999=DK/refused

Q52) How many gallons do you use during the winter months (October – March)?

1. _______Gallons
2. 9999=DK/REF

Q53) How much do you spend per year on oil?

1. $________
2. 9999=DK/REF

Q54) What best describes your use of direct vent heating device during the winter months, from October to May?

a. Day time only	d. Weekend only	h. Not currently using any device

b. Evening only	e. Evening and Weekend only	j. Don't know (do not read)
c. Daytime and evening	f. Occasional use	i. Refused (do not read)

Section 7: Natural Gas Heating Device

(if Q5=1 "yes", ask Q55-Q56, otherwise skip to Q57)

Q55) How much do you spend on natural gas annually?

1. $________
2. DK/REF=9999

Q56) How much do you spend during the winter months, from October to March?

1. $________
2. DK/REF=9999

Section X: Coal Heating Device

(if q6=1 "yes", ask Q57-Q60, otherwise skip to Q61)

Q57) How much coal do you use annually?

1. __tons
2. __bags
3. DK/refused

Q58) How much did you pay for the coal?

1. ___$/bag
2. ___$/ton
3. DK/refused

Q59) How much coal do you use during the winter (October – March)?

1. __tons
2. __bags
3. DK/refused

Q60) Is your coal burned in an indoor stove or an outdoor boiler?

1. Indoor stove
2. Outdoor boiler
3. DK/refused

(Section F: Municipal Heat)

If Q7=1 "yes", ask Q61-Q62, otherwise skip to Q63)

Q61) How much do you spend on municipal heat annually?

1. $________
DK/refused =9999

Q62) How much do you spend on municipal heat during the winter months, October to March?

1. $________
DK/REF=9999

Future Section (to be completed for every survey)

Q63) Do you anticipate acquiring a new or different type of heating device within the next 2 years?

1. Yes
2. No
3. DK/refused

(If Q63=1 "yes", ask Q64, otherwise skip to

Q64) What type of device do you plan to acquire? READ LIST

a. Wood Stove	d. Fuel Oil		h. Don't know (do not read)
b. Wood Pellet	e. Kerosene		i. Refused (do not read)
c. Outdoor Wood Boiler	f. Coal stove	g. Outdoor coal boiler	j Other (Specify)

(If Q64= a. 'Wood stove", ask Q64a, otherwise skip to Q65)

Q64a) Newer EPA certified stoves are more efficient and require less chimney cleaning than older stoves. These benefits ultimately offset the purchase price, particularly if you hire chimney sweepers. How quickly would a new stove need to pay for itself in order for you to buy one?

1. 1 year
2. 2 years
3. 3 years
4. 4 years
5. 5 years or more
6. None
7. Don't Know/Refused (do not read)

Q64b) Would you invest in a new more efficient stove if you were to receive a price incentive paid by either state or local government of $250? (like a rebate)

1. Yes
2. No → ask 64c

if answer to 64 b is no then proceed to 64c:
Q64c) What if the price incentive was $500?

1. Yes
2. No → ask 64d

if answer to 64 c is no then proceed to 64 d:
Q64d) And if the price incentive were $750, would you invest in a new stove?

1. Yes
2. No → ask 64e

if answer to 64 d is no then proceed to 64 e:
Q64e) What if the incentive were $1,000?

1. Yes
2. No → ask 64f

if answer to 64e) is no then proceed to 64f)
Q64F How much of an incentive would it take for you to invest in a new stove?

1. $1000 – 1200
2. $1201 – 1500
3. $1501 – 1750
4. $1751 – 2000
5. $2001 or more
6. DK/refused

(If Q1a=1 or Q12=2 ask Q65-Q68, otherwise skip to Q69)
Q65) Did you burn more wood this winter to minimize the cost of heating oil?
1. Yes
2. No
3. DK/REF

Q66) What fuel oil price would cause you to shift away from using wood for heating? (If respondent is unclear of question ask: If fuel oil prices decline, at what price will you shift to using more fuel oil to heat and decrease the use of wood?)
Specify:____________

Q67) The Borough has contracted with the Cold Climate Housing Research Center (CCHRC) to conduct a study to monitor wood and heating oil used for home heating in Fairbanks during the winter. Data would be collected for a month and there is a $100 incentive for participating. Would you be interested in participating?
1. Yes
2. No
3. DK/REF

Q68) The Borough has also contracted with CCHRC to determine the moisture content of wood used in heating homes in Fairbanks. CCHRC will obtain a sample of wood supplies from fifty homes. Each homeowner will be provided with an equal amount of properly dried wood to replace the sample taken (approximately 10 pieces per household). Would you be interested in participating in this study by allowing us to come to your home and collect about ten pieces of firewood?

1. Yes
2. No
3. DK/REF

(ASK Q69 ONLY IF ZIP=99709, otherwise skip to Q70)

Q69) Can you please tell me whether you live inside of Chena Ridge (to the east of the ridge) or outside of Chena Ridge (to the west of the ridge).

1. Inside Chena Ridge
2. Outside Chena Ridge
3. DK/REF

(ASK Q70 ONLY IF ZIP=99712, otherwise skip to closing statement)

Q70) Can you please tell me if you live inside of Farmers Loop Road or outside of Farmers Loop Road?

1. Inside Farmers Loop Road
2. Outside Farmers Loop Road
3. DK/REF

(ASK ALL)

Q71) How do you keep abreast of current issues is it (read list, allow more than one answer)

1. TV
2. Radio
3. Newspaper
4. Internet
5. Other
6. DK/refused

Thank you, that is all the questions I have this evening. If you have questions or comments about this survey, I can give you the contact information for Hays Research Group. Again, thank you for your time. **(contact information for Hays Research Group is heatsurvey@haysresearch.com NOTE NO 'E' in HAYS, or (907) 277-1025)**

APPENDIX B

2010 Fairbanks Home Heating Survey Tabulated Responses

Section 0: Heating Devices Used and Usage Percentages

Q1 Heating Type - Wood Burning (1-Yes, 2-No, 3-DK)

Count	rzip						
q1	99701	99703	99705	99709	99712	99775	Grand Total
1	15	6	29	47	11		108
2	71	15	32	55	17	1	191
3							
Grand Total	86	21	61	102	28	1	299

Q2 Heating Type - Central Oil Furnace (1-Yes, 2-No, 3-DK)

Count	rzip						
q2	99701	99703	99705	99709	99712	99775	Grand Total
1	78	12	51	81	25		247
2	8	9	10	21	3	1	52
3							
Grand Total	86	21	61	102	28	1	299

Q3 Heating Type - Portable Heater (1-Yes, 2-No, 3-DK)

Count	rzip						
q3	99701	99703	99705	99709	99712	99775	Grand Total
1	2	1	3	4	1		11
2	84	20	58	97	27	1	287
3				1			1
Grand Total	86	21	61	102	28	1	299

Q4 Heating Type - Direct Vent Heater (1-Yes, 2-No, 3-DK)

Count	rzip						
q4	99701	99703	99705	99709	99712	99775	Grand Total
1	11	6	7	22	7		53
2	74	14	54	77	21	1	241
3	1	1		3			5
Grand Total	86	21	61	102	28	1	299

Q5 Heating Type - Natural Gas Heating (1-Yes, 2-No, 3-DK)

Count	rzip						
q5	99701	99703	99705	99709	99712	99775	Grand Total
1	5	4	1	5		1	16
2	80	17	60	97	28		282
3	1						1
Grand Total	86	21	61	102	28	1	299

Q6 Heating Type - Coal Heat (1-Yes, 2-No, 3-DK)

Count	rzip						
q6	99701	99703	99705	99709	99712	99775	Grand Total
1	1		1	2			4
2	85	21	60	100	28	1	295
Grand Total	86	21	61	102	28	1	299

Q7 Heating Type - Municipal Heat (1-Yes, 2-No, 3-DK)

Count	rzip						
q7	99701	99703	99705	99709	99712	99775	Grand Total
1	2	4	1				7
2	79	15	59	100	27	1	281
3	5	2	1	2	1		11
Grand Total	86	21	61	102	28	1	299

Q8 Heating Type - Other Not Listed (1-Yes, 2-No, 3-DK)

Count	rzip						
q8	99701	99703	99705	99709	99712	99775	Grand Total
1	6	1	4	10	1		22
2	79	18	57	90	27	1	272
3	1	2		2			5
Grand Total	86	21	61	102	28	1	299

Counts of Devices Used by Type and ZIP Code

Device Type	99701	99703	99705	99709	99712	99775	All
				Res ZIP			
1 - Wood-Burning	15	6	29	47	11	0	**108**
2 - Central Oil Furnace	78	12	51	81	25	0	**247**
3 - Portable Heater	2	1	3	4	1	0	**11**
4 - Direct Vent Heater	11	6	7	22	7	0	**53**
5 - Natural Gas Heating	5	4	1	5	0	1	**16**
6 - Coal Heat	1	0	1	2	0	0	**4**
7 - Municipal Heat	2	4	1	0	0	0	**7**
8 - Other	6	1	4	10	1	0	**22**
Total	**120**	**34**	**97**	**171**	**45**	**1**	**468**

Multi-Use Households

Item	99701	99703	99705	99709	99712	99775	All
				Res ZIP			
1 thru 7	114	33	93	161	44	1	446
1 thru 8	120	34	97	171	45	1	468
Total HHs	86	21	61	102	28	1	299
% Mult Type	**40%**	**62%**	**59%**	**68%**	**61%**	**0%**	**57%**

QQ Home Area - Square Feet

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	1,770	1,663	2,142	2,084	2,091		1,988

Q1A Wood Burning Type
(1-Fireplace, 2-FP w/insert, 3-Stove, 4-Outdoor Boiler, 5-DK, blank-Not Applicable)

Count	rzip						
q1a	99701	99703	99705	99709	99712	99775	Grand Total
1			3	3			6
2	1	1	1	3	1		7
3	12	4	25	38	10		89
4				1			1
5				1			1
	73	16	32	56	17	1	195
Grand Total	86	21	61	102	28	1	299

Q9 Winter (Oct-March) Use Percentage by Type (Sum)

	rzip						
Data	99701	99703	99705	99709	99712	99775	Grand Total
Wtr Wood Burning	585	205	1745	2052	545	0	5132
Wtr Central Oil	6945	930	3857	6450	1950	0	20132
Wtr Portable	10	50	2	0	0	0	62
Wtr Direct Vent	600	365	215	990	295	0	2465
Natural Gas	400	300	100	445	0	100	1345
Wtr Coal Heat	0	0	5	150	0	0	155
Wtr Municipal Heat	50	245	100	0	0	0	395
Wtr Other Types	10	5	76	113	10	0	214

Q9 Winter (Oct-March) Use Responses by Type

Count	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	86	21	61	102	28	1	299

Q9 Winter (Oct-March) Average Use Percentage by Type

Data	99701	99703	99705	99709	99712	99775	Grand Total
				Res ZIP			
Wtr Wood Burning	6.8%	9.8%	28.6%	20.1%	19.5%	0.0%	17.2%
Wtr Central Oil	80.8%	44.3%	63.2%	63.2%	69.6%	0.0%	67.3%
Wtr Portable	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	0.2%
Wtr Direct Vent	7.0%	17.4%	3.5%	9.7%	10.5%	0.0%	8.2%
Natural Gas	4.7%	14.3%	1.6%	4.4%	0.0%	100.0%	4.5%
Wtr Coal Heat	0.0%	0.0%	0.1%	1.5%	0.0%	0.0%	0.5%
Wtr Municipal Heat	0.6%	11.7%	1.6%	0.0%	0.0%	0.0%	1.3%
Wtr Other Types	0.1%	0.2%	1.2%	1.1%	0.4%	0.0%	0.7%
Grand Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Section 1: Wood-Burning Stove or Fireplace with Insert

Q10A Wood Stove/Insert Age (1-: <1988, 2: >1988, 3-DK, blank-Not Applicable)

Count	rzip						
q10a	99701	99703	99705	99709	99712	99775	Grand Total
1	2	3	12	13	1		31
2	10	2	14	25	9		60
3	1			3	1		5
	73	16	35	61	17	1	203
Grand Total	86	21	61	102	28	1	299

Q11A Wood Stove/Insert Ages, Years
(1: <1, 2: 1-5, 3: 5-10, 4: 10-15, 5: 15+, 6: DK, blank-Not Applicable)

Count	rzip						
q11a>1	99701	99703	99705	99709	99712	99775	Grand Total
1	2		1	1	1		5
2	1	1	11	9	4		26
3	3		1	6	2		12
4	4	1	3	6			14
5	1	2	9	17	1		30
6	2	1	1	2	3		9
	73	16	35	61	17	1	203
Grand Total	86	21	61	102	28	1	299

Q11A Wood Stove/Insert Ages, Years
(1: <1, 2: 1-5, 3: 5-10, 4: 10-15, 5: 15+, 6: DK, blank-Not Applicable)

Count	rzip						
q11a>2	99701	99703	99705	99709	99712	99775	Grand Total
2	1						1
5	1						1
	84	21	61	102	28	1	297
Grand Total	86	21	61	102	28	1	299

Q11B Wood Stove/Insert Catalytic (1-Catalytic, 2-Non-Catalytic, 3-DK, blank-Not Applicable)

Count	rzip						
q11b	99701	99703	99705	99709	99712	99775	Grand Total
1	4	2	9	15	5		35
2	5	3	13	22	5		48
3	4		4	4	1		13
	73	16	35	61	17	1	203
Grand Total	86	21	61	102	28	1	299

Q12 Wood Stove/Insert Fuel (1-Pellets, 2-Cord Wood 3-DK, blank-Not Applicable)

Count	rzip						
q12>1	99701	99703	99705	99709	99712	99775	Grand Total
1	1			2	1		4
2	11	5	26	38	10		90
3	1			1			2
	73	16	35	61	17	1	203
Grand Total	86	21	61	102	28	1	299

Q13 Wood Stove/Insert Burning Daily Profile - Winter
(1-Day, 2-Eve, 3-Day & Eve, 4-Weekend, 5-Eve & Weekend,
6-Occasional, 7-Not Currently Using, 8-DK, 9-Ref, blank-Not Applicable)

Count	rzip						
q13	99701	99703	99705	99709	99712	99775	Grand Total
1		1		4			5
2		1	2	3			6
3	4	1	16	20	7		48
4	1						1
5	2	2	4	6	1		15
6	1		3	5	2		11
7	2						2
8			1				1
9	1						1
	75	16	35	64	18	1	209
Grand Total	86	21	61	102	28	1	299

Q14 Wood Stove/Insert Source (1-Buy, 2-Cut own, 3-DK, blank-Not Applicable)

Count	rzip						
q14>1	99701	99703	99705	99709	99712	99775	Grand Total
1	6	2	9	17			34
2	5	3	17	21	10		56
	75	16	35	64	18	1	209
Grand Total	86	21	61	102	28	1	299

Q14 Wood Stove/Insert Source (1-Buy, 2-Cut own, 3-DK, blank-Not Applicable)

Count	rzip						
q14>2	99701	99703	99705	99709	99712	99775	Grand Total
2	5	2	6	4			17
	81	19	55	98	28	1	282
Grand Total	86	21	61	102	28	1	299

Q15 Wood Stove/Insert Cutting Permit (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q15	99701	99703	99705	99709	99712	99775	Grand Total
1	5	2	11	8	4		30
2	5	3	12	16	6		42
3				1			1
	76	16	38	77	18	1	226
Grand Total	86	21	61	102	28	1	299

Q16 Wood Stove/Insert Seasoning (Month, 9999-DK)

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	13.0	15.0	15.3	16.5	8.3	#DIV/0!	14.4

Q17 Wood Stove/Insert Moisture Content (Percent, 9999-DK)

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	1.0	#DIV/0!	7.3	8.3	11.3	#DIV/0!	7.9

Q18 Wood Stove/Insert Wood Cords Used - Annual

Annual Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	3.50	3.50	5.23	3.54	3.30	#DIV/0!	3.95

Q19 Wood Stove/Insert Wood Cords Used - Winter (Oct-March)

Winter Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	3.10	3.25	4.71	3.28	2.70	#DIV/0!	3.60

Q20 Wood Stove/Insert Pellet Bags Used - Annual

Annual Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	250	#DIV/0!	#DIV/0!	9	150	#DIV/0!	104.5

Q21 Wood Stove/Insert Pellet Bags Used - Winter (Oct-March)

Winter Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	175	#DIV/0!	#DIV/0!	8	130	#DIV/0!	80

Q22 Wood Stove/Insert Wood Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	100	1800	610	#DIV/0!	#DIV/0!	1120

Q23 Wood Stove/Insert Pellets Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Section 2: Wood-Burning Fireplace (no insert)

Q24 Wood Fireplace Burning Daily Profile - Winter
(1-Day, 2-Eve, 3-Day & Eve, 4-Weekend, 5-Eve & Weekend,
6-Occasional, 7-Not Currently Using, 8-DK, 9-Ref, blank-Not Applicable)

Count	rzip						
q24	99701	99703	99705	99709	99712	99775	Grand Total
3			3	1			4
5				2			2
	86	21	58	99	28	1	293
Grand Total	86	21	61	102	28	1	299

Q25 Wood Fireplace Source (1-Buy, 2-Cut own, 3-DK, blank-Not Applicable)

Count	rzip						
q25>1	99701	99703	99705	99709	99712	99775	Grand Total
1			1	1			2
2			2	1			3
3				1			1
	86	21	58	99	28	1	293
Grand Total	86	21	61	102	28	1	299

Q25 Wood Fireplace Source (1-Buy, 2-Cut own, 3-DK, blank-Not Applicable)

Count	rzip						
q25>2	99701	99703	99705	99709	99712	99775	Grand Total
2			1	1			2
	86	21	60	101	28	1	297
Grand Total	86	21	61	102	28	1	299

Q26 Wood Fireplace Cutting Permit (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q26	99701	99703	99705	99709	99712	99775	Grand Total
1			1	2			3
2			2				2
	86	21	58	100	28	1	294
Grand Total	86	21	61	102	28	1	299

Q27 Wood Fireplace Seasoning (Month, 9999-DK)

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	5.67	18	#DIV/0!	#DIV/0!	10.6

Q28 Wood Fireplace Moisture Content (Percent, 9999-DK)

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Q29 Wood Fireplace Wood Cords Used - Annual

Annual Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	6	4	#DIV/0!	#DIV/0!	5.20

Q30 Wood Fireplace Wood Cords Used - Winter (Oct-March)

Winter Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	5.67	3	#DIV/0!	#DIV/0!	4.60

Q31 Wood Fireplace Wood Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	143.33	630	#DIV/0!	#DIV/0!	338

Section 3: Outdoor Wood Boiler

Q32 Outdoor Wood Boiler Burning Daily Profile - Winter (1-Day, 2-Eve, 3-Day & Eve, 4-Weekend, 5-Eve & Weekend, 6-Occasional, 7-Not Currently Using, 8-DK, 9-Ref, blank-Not Applicable)

Count	rzip						
q32	99701	99703	99705	99709	99712	99775	Grand Total
7				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q33 Outdoor Wood Boiler Source (1-Buy, 2-Cut own, 3-DK, blank-Not Applicable)

Count	rzip						
q33>1	99701	99703	99705	99709	99712	99775	Grand Total
2				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q34 Outdoor Wood Boiler Cutting Permit (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q34	99701	99703	99705	99709	99712	99775	Grand Total
2				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q35 Outdoor Wood Boiler Seasoning (Months, 9999-DK)

Average	rzip						
q35	99701	99703	99705	99709	99712	99775	Grand Total
24				24			24
	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Grand Total	#DIV/0!	#DIV/0!	#DIV/0!	24	#DIV/0!	#DIV/0!	24

Q36 Outdoor Wood Boiler Moisture Content (Percent, 9999-DK)

Average of q36	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Q37 Outdoor Wood Boiler Cords Used - Annual

Annual Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total				6			6

Q38 Outdoor Wood Boiler Cords Used - Winter (Oct-March)

Winter Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total				6			6

Q39 Outdoor Wood Boiler Wood Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Section 4: Central Oil Furnace

Q41 Central Oil Fuel Tank Size, Gallons

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	582	600	514	703	624	#DIV/0!	611

Q42 Central Oil Use - Annual, Gallons

Annual Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	1,258	1,083	996	1,141	1,053	#DIV/0!	1,135

Q43 Central Oil Use - Winter (Oct-March), Gallons

Winter Avg	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	805	875	749	883	781	#DIV/0!	818

Q44 Central Oil Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	3,309	2,600	2,992	3,600	3,019	#DIV/0!	3,272

Section 5: Portable Fuel Oil/Kerosene Heating Device

Q45 Portable Heater Fuel Oil Use (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q45	99701	99703	99705	99709	99712	99775	Grand Total
1	1	1	2	1	1		6
2	1		1	3			5
3				1			1
	84	20	58	97	27	1	287
Grand Total	86	21	61	102	28	1	299

Q46 Portable Heater Kerosene Use (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q46	99701	99703	99705	99709	99712	99775	Grand Total
1	1	1	2	1			5
2	1		1	3	1		6
3				1			1
	84	20	58	97	27	1	287
Grand Total	86	21	61	102	28	1	299

Q47 Portable Heater Fuel Use - Annual, Gallons

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	20	2	300	#DIV/0!	107

Q48 Portable Heater Fuel Use - Winter (Oct-March), Gallons

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	#DIV/0!	#DIV/0!	20	2	300	#DIV/0!	107

Q49 Portable Heater Fuel Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	$2,500	$0	$1,135	$1,650	$300	#DIV/0!	$1,196

Q50 Central/Portable/Other Heating Daily Profile - Winter
(1-Day, 2-Eve, 3-Day & Eve, 4-Weekend, 5-Eve & Weekend,
6-Occasional, 7-Not Currently Using, 8-DK, 9-Ref, blank-Not Applicable)

Count	rzip						
q50	99701	99703	99705	99709	99712	99775	Grand Total
1	2		2	3			7
2		2		1			3
3	70	9	39	69	16		203
5			1	3	1		5
6		1	6	2	3		12
7	4	1	2	3	2		12
8	1			2	2		5
9			1	1	1		3
	9	8	10	18	3	1	49
Grand Total	86	21	61	102	28	1	299

Section 6: Toyo, Monitor, or Other Direct-Vent Heater

Q51 Direct Vent Heater Only Fuel Use - Annual, Gallons

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	700	#DIV/0!	733	403	417	#DIV/0!	493

Q52 Direct Vent Heater Only Fuel Use - Winter (Oct-March), Gallons

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	625	#DIV/0!	633	311	417	#DIV/0!	444

Q53 Direct Vent Heater Fuel Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	2,225	100	850	1,417	1,375	#DIV/0!	1,389

Q54 Direct Vent Heater Heating Daily Profile - Winter
(1-Day, 2-Eve, 3-Day & Eve, 4-Weekend, 5-Eve & Weekend,
6-Occasional, 7-Not Currently Using, 8-DK, 9-Ref, blank-Not Applicable)

Count of q54	rzip						
q54	99701	99703	99705	99709	99712	99775	Grand Total
1	1		1	1			3
2		1	1		1		3
3	9	4	3	15	4		35
5				1			1
6		1	2	1			4
7	2				1		3
8				2	2		4
9				1			1
	74	15	54	81	20	1	245
Grand Total	86	21	61	102	28	1	299

Section 7: Natural Gas Heating Device

Q55 Natural Gas Heating Fuel Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	$1,950	$900	n/a	$2,717	n/a	n/a	$2,159

Q56 Natural Gas Heating Fuel Cost - Winter (Oct-March), Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	$1,700	$700	#DIV/0!	$1,180	#DIV/0!		$1,260

Section X: Coal Heating Device

Q57 Coal Use - Annual, Bags

Average	rzip						
	99701	99702	99703	99705	99709	99775	Grand Total
Total	9						9

Q58 Coal Cost - Annual, Dollars/Bag

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total				$108			$108

Q59 Coal Cost - Winter (Oct-March), Dollars/Bag

Average	rzip						
	99701	99702	99703	99705	99709	99775	Grand Total
Total							

Q60 Coal Heating Place (1-Indoor Stove, 2-Outdoor Boiler, blank-Not Applicable)

Count	rzip						
q60	99701	99703	99705	99709	99712	99775	Grand Total
1			1	1			2
2	1			1			2
	85	21	60	100	28	1	295
Grand Total	86	21	61	102	28	1	299

Section F: Municipal Heat

Q61 Municipal Heating Fuel Cost - Annual, Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	$2,800	$2,000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	$2,400

Q62 Municipal Heating Fuel Cost - Winter (Oct-March), Dollars

Average	rzip						
	99701	99703	99705	99709	99712	99775	Grand Total
Total	$1,500	$1,200	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	$1,350

Future Use Section

Q63 Planned New or Different Heating Device (1-Yes, 2-No, 3-DK)

Count	rzip						
q63	99701	99703	99705	99709	99712	99775	Grand Total
1	16	1	10	13	10		50
2	69	18	49	87	18	1	242
3	1	2	2	2			7
Grand Total	86	21	61	102	28	1	299

Q64 Planned New/Replacement Device Type
(1-Wood, 2-Pellet, 3-Outdoor wood boiler 4-Fuel oil, 5-Kerosene, blank-Not Applicable)

Count	rzip						
q65	99701	99703	99705	99709	99712	99775	Grand Total
1	6	3	12	14	3		38
2	5	2	16	26	7		56
3			1	1			2
	75	16	32	61	18	1	203
Grand Total	86	21	61	102	28	1	299

Q64a Offset Years to Buy a New Wood Stove
(1: 1 yr, 2: 2 yrs, 3: 3 yrs, 4: 4 yrs, 5: 5+ yrs, 6: None, 7: DK, blank: Not Applicable)

Count	rzip						
q64a	99701	99703	99705	99709	99712	99775	Grand Total
1	1			1			2
2	1		2				3
3	1			2			3
4				1			1
5			1	1	1		3
7				1	1		2
	83	21	58	96	26	1	285
Grand Total	86	21	61	102	28	1	299

Q64b Willing to Buy a New Stove with $250 Incentive (1-Yes, 2-No, blank-Not Applicable)

Count	rzip						
q64b	99701	99703	99705	99709	99712	99775	Grand Total
1	3		2	5			10
2			1	1	2		4
	83	21	58	96	26	1	285
Grand Total	86	21	61	102	28	1	299

Q64c Willing to Buy a New Stove with $500 Incentive (1-Yes, 2-No, blank-Not Applicable)

Count	rzip						
q64c	99701	99703	99705	99709	99712	99775	Grand Total
1			1		2		3
2				1			1
	86	21	60	101	26	1	295
Grand Total	86	21	61	102	28	1	299

Q64d Willing to Buy a New Stove with $750 Incentive (1-Yes, 2-No, blank-Not Applicable)

Count of q64d	rzip						
q64d	99701	99703	99705	99709	99712	99775	Grand Total
2				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q64e Willing to Buy a New Stove with $1000 Incentive (1-Yes, 2-No, blank-Not Applicable)

Count of q64e	rzip						
q64e	99701	99703	99705	99709	99712	99775	Grand Total
2				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q64f Amonunt of Incentive to to Buy a New Wood Stove (1: $1000-$1200, 2: $1201-$1500, 3: $1501-$1750, 4: $1751-$2000, 5: $2001 or more, 6: DK, blank-Not Applicable)

Count	rzip						
q64f	99701	99703	99705	99709	99712	99775	Grand Total
6				1			1
	86	21	61	101	28	1	298
Grand Total	86	21	61	102	28	1	299

Q65 Burned More Wood Last Winter (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q65	99701	99703	99705	99709	99712	99775	Grand Total
1	6	3	12	14	3		38
2	5	2	16	26	7		56
3			1	1			2
	75	16	32	61	18	1	203
Grand Total	86	21	61	102	28	1	299

Q66 Fuel Oil Price To Stop Using Wood, Dollars

	rzip						
Data	99701	99703	99705	99709	99712	99775	Grand Total
Average	$1.46	$1.95	$1.74	$1.78	$2.00		$1.74
Min	$0.50	$1.95	$0.85	$0.00	$1.00		$0.00
Max	$2.00	$1.95	$3.51	$5.00	$3.00		$5.00
StdDev	$0.61	#DIV/0!	$0.79	$1.27	$1.00		$1.04
Households That Would Always Burn Wood	3	0	3	5	0	0	11
Households That Say "Much Cheaper"	1	1	1	1	1	0	5

Q67 Willing to Participate in Monitoring Wood & Heating Oil Use (1-Yes, 2-No, 3-DK, blank-Not Applicable)

Count	rzip						
q67	99701	99703	99705	99709	99712	99775	Grand Total
1	8	4	13	27	5		57
2	1	1	13	13	5		33
3	2		3	1			6
	75	16	32	61	18	1	203
Grand Total	86	21	61	102	28	1	299

Q68 Willing to Participate in Determining Moisture Content of Wood (1-Yes, 2-No, blank-Not Applicable)

Count of q68	rzip						
q68	99701	99703	99705	99709	99712	99775	Grand Total
1	6	4	12	29	7		58
2	5	1	16	12	3		37
3			1				1
	75	16	32	61	18	1	203
Grand Total	86	21	61	102	28	1	299

Q69 Live Inside/Outside of Chena Ridge (1-Inside, 2-Outside, 3-DK, blank-Not Applicable)

Count	rzip						
q69	99701	99703	99705	99709	99712	99775	Grand Total
1				29			29
2				57			57
3				16			16
	86	21	61		28	1	197
Grand Total	86	21	61	102	28	1	299

Q70 Live Inside/Outside of Farmers Loop Road (1-Inside, 2-Outside, 3-DK/Ref, blank-Not Applicable)

Count	rzip						
q70	99701	99703	99705	99709	99712	99775	Grand Total
1					1		1
2					26		26
3					1		1
	86	21	61	102		1	271
Grand Total	86	21	61	102	28	1	299

Q71 Media Watch : Keeping Abreast of Current Issues
(1-TV, 2-Radio, 3-Newspaper, 4-Internet, 5-Other, 6-DK, blank-Not Applicable)

Sum of q71>1	rzip						
q71>1	99701	99703	99705	99709	99712	99775	Grand Total
1	53	14	35	57	14	1	174
2	18	4	14	36	10		82
3	45	3	24	54	3		129
4	24	8	40	28	16		116
5	10	5	5	5	15		40
6	6	6		6	6		24
Grand Total	156	40	118	186	64	1	565

Q71 Media Watch : Keeping Abreast of Current Issues
(1-TV, 2-Radio, 3-Newspaper, 4-Internet, 5-Other, 6-DK, blank-Not Applicable)

Count of q71>2	rzip						
q71>2	99701	99703	99705	99709	99712	99775	Grand Total
2	26	9	18	37	10	1	101
3	14	3	8	22	3		50
4	7	1	14	10	3		35
5	2			1			3
	37	8	21	32	12		110
Grand Total	86	21	61	102	28	1	299

Q71 Media Watch : Keeping Abreast of Current Issues
(1-TV, 2-Radio, 3-Newspaper, 4-Internet, 5-Other, 6-DK, blank-Not Applicable)

Count of q71>3	rzip						
q71>3	99701	99703	99705	99709	99712	99775	Grand Total
3	23	7	15	30	8	1	84
4	4	1	3	16	1		25
5	1			1			2
	58	13	43	55	19		188
Grand Total	86	21	61	102	28	1	299

Q71 Media Watch : Keeping Abreast of Current Issues
(1-TV, 2-Radio, 3-Newspaper, 4-Internet, 5-Other, 6-DK, blank-Not Applicable)

Count of q71>4	rzip						
q71>4	99701	99703	99705	99709	99712	99775	Grand Total
4	18	7	13	22	8	1	69
5	1						1
	67	14	48	80	20		229
Grand Total	86	21	61	102	28	1	299

Q71 Media Watch : Keeping Abreast of Current Issues
(1-TV, 2-Radio, 3-Newspaper, 4-Internet, 5-Other, 6-DK, blank-Not Applicable)

Count of q71>5	rzip						
q71>5	99701	99703	99705	99709	99712	99775	Grand Total
5	10	2	2	10	4		28
	76	19	59	92	24	1	271
Grand Total	86	21	61	102	28	1	299

APPENDIX C

2010 Fairbanks Home Heating Survey Normalized Tabulations

TABULATIONS OF FAIRBANKS 2010 HOME HEATING SURVEY

Parameter	Stat	Type	99701 Downtown	99703 Wainwright	99705 North Pole	99709 Airport	99712 Steese	99775 University	All All
Survey Sample	# Obs		86	21	61	102	28	1	299
(Self-weighted by ZIP households)	% Obs		**28.8%**	**7.0%**	**20.4%**	**34.1%**	**9.4%**	**0.3%**	**100.0%**
Multiple Type Heating	UseFactor	(1.0=Single)	**1.40**	**1.62**	**1.59**	**1.68**	**1.61**	**1.00**	**1.57**
Average Use by Type, Winter (October-March)	**% Obs**	**Wood**	**6.8%**	**9.8%**	**28.6%**	**20.1%**	**19.5%**	**0.0%**	**17.2%**
	% Obs	**Central Oil**	**80.8%**	**44.3%**	**63.2%**	**63.2%**	**69.6%**	**0.0%**	**67.3%**
	% Obs	**Portable**	**0.1%**	**2.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**
	% Obs	**Direct Vent**	**7.0%**	**17.4%**	**3.5%**	**9.7%**	**10.5%**	**0.0%**	**8.2%**
	% Obs	**Natural Gas**	**4.7%**	**14.3%**	**1.6%**	**4.4%**	**0.0%**	**100.0%**	**4.5%**
	% Obs	**Coal Heat**	**0.0%**	**0.0%**	**0.1%**	**1.5%**	**0.0%**	**0.0%**	**0.5%**
	% Obs	**Muni. Heat**	**0.6%**	**11.7%**	**1.6%**	**0.0%**	**0.0%**	**0.0%**	**1.3%**
	% Obs	**Other**	**0.1%**	**0.2%**	**1.2%**	**1.1%**	**0.4%**	**0.0%**	**0.7%**
		All	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Wood Burning Type (Q1a)	# Obs	Fireplace	0	0	3	3	0	0	6
	# Obs	FP+Insert	1	1	1	3	1	0	7
	# Obs	Stove	12	4	25	38	10	0	89
	# Obs	Wood Boiler	0	0	0	1	0	0	1
	# Obs	Unknown	0	0	0	1	0	0	1
	# Obs	N/A	73	16	32	56	17	1	195
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	13	5	29	45	11	0	103
	% Obs	**Fireplace**	**0.0%**	**0.0%**	**10.3%**	**6.7%**	**0.0%**	**0.0%**	**5.8%**
	% Obs	**FP+Insert**	**7.7%**	**20.0%**	**3.4%**	**6.7%**	**9.1%**	**0.0%**	**6.8%**
	% Obs	**Stove**	**92.3%**	**80.0%**	**86.2%**	**84.4%**	**90.9%**	**0.0%**	**86.4%**
	% Obs	**Wood Boiler**	**0.0%**	**0.0%**	**0.0%**	**2.2%**	**0.0%**	**0.0%**	**1%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Wood Stove/Insert Installation Year / Cert Type (Q10a)	# Obs	<1988 (Un-Certified)	2	3	12	13	1	0	31
	# Obs	>=1988 (Certified)	10	2	14	25	9	0	60
	# Obs	Unknown	1	0	0	3	1	0	5
	# Obs	N/A	73	16	35	61	17	1	203
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	12	5	26	38	10	0	91
	% Obs	**<1988 (Un-Certified)**	**16.7%**	**60.0%**	**46.2%**	**34.2%**	**10.0%**	**0.0%**	**34.1%**
	% Obs	**>=1988 (Certified)**	**83.3%**	**40.0%**	**53.8%**	**65.8%**	**90.0%**	**0.0%**	**65.9%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Wood Stove/Insert Fuel Type (Q12)	# Obs	Pellets	1	0	0	2	1	0	4
	# Obs	Cord Wood	11	5	26	38	10	0	90
	# Obs	Unknown	1	0	0	1	0	0	2
	# Obs	N/A	73	16	35	61	17	1	203
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	12	5	26	40	11	0	94
	% Obs	**Pellets**	**8.3%**	**0.0%**	**0.0%**	**5.0%**	**9.1%**	**0.0%**	**4.3%**
	% Obs	**Cord Wood**	**91.7%**	**100.0%**	**100.0%**	**95.0%**	**90.9%**	**0.0%**	**95.7%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Wood Stove/Insert Daily Use Profile, Winter (Q13)	# Obs	Daytime	0	1	0	4	0	0	5
	# Obs	Evening	0	1	2	3	0	0	6
	# Obs	Day&Eve	4	1	16	20	7	0	48
	# Obs	Weekend	1	0	0	0	0	0	1
	# Obs	Eve&WkEnd	2	2	4	6	1	0	15
	# Obs	Occasional	1	0	3	5	2	0	11
	# Obs	Not Using	2	0	0	0	0	0	2
	# Obs	Unknown	0	0	1	0	0	0	1
	# Obs	N/A	1	0	0	0	0	0	1
	# Obs	All	75	16	35	64	18	1	209
	# Obs	All With	10	5	25	38	10	0	88
	% Obs	**Daytime**	**0.0%**	**20.0%**	**0.0%**	**10.5%**	**0.0%**	**0.0%**	**5.7%**
	% Obs	**Evening**	**0.0%**	**20.0%**	**8.0%**	**7.9%**	**0.0%**	**0.0%**	**6.8%**
	% Obs	**Day&Eve**	**40.0%**	**20.0%**	**64.0%**	**52.6%**	**70.0%**	**0.0%**	**54.5%**
	% Obs	**Weekend**	**10.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.1%**
	% Obs	**Eve&WkEnd**	**20.0%**	**40.0%**	**16.0%**	**15.8%**	**10.0%**	**0.0%**	**17.0%**
	% Obs	**Occasional**	**10.0%**	**0.0%**	**12.0%**	**13.2%**	**20.0%**	**0.0%**	**12.5%**
	% Obs	**Not Using**	**20.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**2.3%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Wood Stove/Insert Wood Source (Q14)	# Obs	Cut Own-multi response	5	2	6	4	0	0	17
	# Obs	Buy	6	2	9	17	0	0	34
	# Obs	Cut Own	5	3	17	21	10	0	56
	# Obs	Unknown	75	16	35	64	18	1	209
	# Obs	N/A	86	21	61	102	28	1	299
	# Obs	All	0	0	0	0	0	0	0
	# Obs	All With	11	5	26	38	10	0	90
	% Obs	**Buy**	**54.5%**	**40.0%**	**34.6%**	**44.7%**	**0.0%**	**0.0%**	**37.8%**
	% Obs	**Cut Own**	**90.9%**	**100.0%**	**88.5%**	**65.8%**	**100.0%**	**0.0%**	**81.1%**
	% Obs	**All With**	**145.5%**	**140.0%**	**123.1%**	**110.5%**	**100.0%**	**0.0%**	**118.9%**
Wood Stove/Insert Cutting Permit Obtained (Q15)	# Obs	Yes	5	2	11	8	4	0	30
	# Obs	No	5	3	12	16	6	0	42
	# Obs	Unknown	0	0	0	1	0	0	1
	# Obs	N/A	76	16	38	77	18	1	226
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	10	5	23	24	10	0	72
	% Obs	**Yes**	**50.0%**	**40.0%**	**47.8%**	**33.3%**	**40.0%**	**0.0%**	**41.7%**
	% Obs	**No**	**50.0%**	**60.0%**	**52.2%**	**66.7%**	**60.0%**	**0.0%**	**58.3%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**

TABULATIONS OF FAIRBANKS 2010 HOME HEATING SURVEY									
			99701	99703	99705	99709	99712	99775	All
Parameter	Stat	Type	Downtown	Wainwright	North Pole	Airport	Steese	University	All
Wood Fireplace Daily Use Profile, Winter (Q24)	# Obs	Daytime							
	# Obs	Evening							
	# Obs	Day&Eve	0	0	3	1	0	0	4
	# Obs	Weekend							
	# Obs	Eve&WkEnd	0	0	0	2	0	0	2
	# Obs	Occasional							
	# Obs	Not Using							
	# Obs	Unknown							
	# Obs	N/A	86	21	58	99	28	1	293
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	0	0	3	3	0	0	6
	% Obs	**Daytime**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	% Obs	**Evening**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	% Obs	**Day&Eve**	**0.0%**	**0.0%**	**100.0%**	**33.3%**	**0.0%**	**0.0%**	**66.7%**
	% Obs	**Weekend**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	% Obs	**Eve&WkEnd**	**0.0%**	**0.0%**	**0.0%**	**66.7%**	**0.0%**	**0.0%**	**33.3%**
	% Obs	**Occasional**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	% Obs	**Not Using**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
	% Obs	**All With**	**0.0%**	**0.0%**	**100.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**
Wood Fireplace Wood Source (Q25)	# Obs	Buy	0	0	1	1	0	0	2
	# Obs	Cut Own	0	0	2	1	0	0	3
	# Obs	Unknown	0	0	0	1	0	0	1
	# Obs	N/A	86	21	58	99	28	1	293
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	0	0	3	2	0	0	5
	% Obs	**Buy**	**0.0%**	**0.0%**	**33.3%**	**50.0%**	**0.0%**	**0.0%**	**40.0%**
	% Obs	**Cut Own**	**0.0%**	**0.0%**	**66.7%**	**50.0%**	**0.0%**	**0.0%**	**60.0%**
	% Obs	**All With**	**0.0%**	**0.0%**	**100.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**
Wood Fireplace Cutting Permit Obtained (Q26)	# Obs	Yes	0	0	1	2	0	0	3
	# Obs	No	0	0	2	0	0	0	2
	# Obs	Unknown							
	# Obs	N/A	86	21	58	100	28	1	294
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	0	0	3	2	0	0	5
	% Obs	**Yes**	**0.0%**	**0.0%**	**33.3%**	**100.0%**	**0.0%**	**0.0%**	**60.0%**
	% Obs	**No**	**0.0%**	**0.0%**	**66.7%**	**0.0%**	**0.0%**	**0.0%**	**40.0%**
	% Obs	**All With**	**0.0%**	**0.0%**	**100.0%**	**100.0%**	**0.0%**	**0.0%**	**100.0%**
Stove/Insert Wood Use (cords), Annual (Q18)	**Average**	**Per Equipped Household**	**3.50**	**3.50**	**5.23**	**3.54**	**3.30**	**#DIV/0!**	**3.95**
Stove/Insert Wood Use (cords), Winter (Q19)	**Average**	**Per Equipped Household**	**3.10**	**3.25**	**4.71**	**3.28**	**2.70**	**#DIV/0!**	**3.60**
Fireplace Wood Use (cords), Annual (Q29)	**Average**	**Per Equipped Household**	**#DIV/0!**	**#DIV/0!**	**6.00**	**4.00**	**#DIV/0!**	**#DIV/0!**	**5.20**
Fireplace Wood Use (cords), Winter (Q30)	**Average**	**Per Equipped Household**	**#DIV/0!**	**#DIV/0!**	**5.67**	**3.00**	**#DIV/0!**	**#DIV/0!**	**4.60**
Central Oil Use (gallons), Annual (Q42)	**Average**	**Per Equipped Household**	**1,258**	**1,083**	**996**	**1,141**	**1,053**	**#DIV/0!**	**1,135**
Central Oil Use (gallons), Winter (Q43)	**Average**	**Per Equipped Household**	**805**	**875**	**749**	**883**	**781**	**#DIV/0!**	**818**
Central Oil, Portable Heater Daily Use Profile, Winter (Q50)	# Obs	Daytime	2	0	2	3	0	0	7
	# Obs	Evening	0	2	0	1	0	0	3
	# Obs	Day&Eve	70	9	39	69	16	0	203
	# Obs	Weekend	0	0	1	3	1	0	5
	# Obs	Eve&WkEnd	0	1	6	2	3	0	12
	# Obs	Occasional	4	1	2	3	2	0	12
	# Obs	Not Using	1	0	0	2	2	0	5
	# Obs	Unknown	0	0	1	1	1	0	3
	# Obs	N/A	9	8	10	18	3	1	49
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	77	13	50	83	24	0	247
	% Obs	**Daytime**	**2.6%**	**0.0%**	**4.0%**	**3.6%**	**0.0%**	**0.0%**	**2.8%**
	% Obs	**Evening**	**0.0%**	**15.4%**	**0.0%**	**1.2%**	**0.0%**	**0.0%**	**1.2%**
	% Obs	**Day&Eve**	**90.9%**	**69.2%**	**78.0%**	**83.1%**	**66.7%**	**0.0%**	**82.2%**
	% Obs	**Weekend**	**0.0%**	**0.0%**	**2.0%**	**3.6%**	**4.2%**	**0.0%**	**2.0%**
	% Obs	**Eve&WkEnd**	**0.0%**	**7.7%**	**12.0%**	**2.4%**	**12.5%**	**0.0%**	**4.9%**
	% Obs	**Occasional**	**5.2%**	**7.7%**	**4.0%**	**3.6%**	**8.3%**	**0.0%**	**4.9%**
	% Obs	**Not Using**	**1.3%**	**0.0%**	**0.0%**	**2.4%**	**8.3%**	**0.0%**	**2.0%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Portable Heater Fuel Type (Q45 & Q46)	# Obs	Fuel Oil - Yes	1	1	2	1	1	0	6
	# Obs	Fuel Oil - No	1	0	1	3	0	0	5
	# Obs	Kerosene - Yes	1	1	2	1	0	0	5
	# Obs	Kerosene - No	1	0	1	3	1	0	6
	# Obs	Unknown	0	0	0	1	0	0	1
	# Obs	N/A	84	20	58	97	27	1	287
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	2	1	3	4	1	0	11
	% Obs	**Fuel Oil**	**50.0%**	**50.0%**	**50.0%**	**50.0%**	**100.0%**	**0.0%**	**54.5%**
	% Obs	**Kerosene**	**50.0%**	**50.0%**	**50.0%**	**50.0%**	**0.0%**	**0.0%**	**45.5%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Portable Heater Fuel Use (gallons), Annual (Q47)	**Average**	**Per Equipped Household**	**#DIV/0!**	**#DIV/0!**	**20**	**2**	**300**	**#DIV/0!**	**107**
Portable Heater Fuel Use (gallons), Winter (Q48)	**Average**	**Per Equipped Household**	**#DIV/0!**	**#DIV/0!**	**20**	**2**	**300**	**#DIV/0!**	**107**
Direct Vent Heater Fuel Use (gallons), Annual (Q51)	**Average**	**Per Equipped Household**	**700**	**#DIV/0!**	**733**	**403**	**417**	**#DIV/0!**	**493**
Direct Vent Heater Fuel Use (gallons), Winter (Q52)	**Average**	**Per Equipped Household**	**625**	**#DIV/0!**	**633**	**311**	**417**	**#DIV/0!**	**444**
Natural Gas Heating Fuel Cost (dollars), Annual (Q55)	**Average**	**Per Equipped Household**	**$1,950**	**$900**	**n/a**	**$2,717**	**n/a**	**n/a**	**$2,159**
Natural Gas Heating Fuel Cost (dollars), Winter (Q56)	**Average**	**Per Equipped Household**	**$1,700**	**$700**	**#DIV/0!**	**$1,180**	**#DIV/0!**	**$0**	**$1,260**
Municipal Heating Fuel Cost (dollars), Annual (Q61)	**Average**	**Per Equipped Household**	**$2,800**	**$2,000**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**$2,400**
Municipal Heating Fuel Cost (dollars), Winter (Q62)	**Average**	**Per Equipped Household**	**$1,500**	**$1,200**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**$1,350**

TABULATIONS OF FAIRBANKS 2010 HOME HEATING SURVEY

Parameter	Stat	Type	99701 Downtown	99703 Wainwright	99705 North Pole	99709 Airport	99712 Steese	99775 University	All All
Planned New or Different Heating within 2 Yrs (Q63)	# Obs	Yes	16	1	10	13	10	0	50
	# Obs	No	69	18	49	87	18	1	242
	# Obs	Unknown	1	2	2	2	0	0	7
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	85	19	59	100	28	1	292
	% Obs	**Yes**	**18.8%**	**5.3%**	**16.9%**	**13.0%**	**35.7%**	**0.0%**	**17.1%**
	% Obs	**No**	**81.2%**	**94.7%**	**83.1%**	**87.0%**	**64.3%**	**100.0%**	**82.9%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Burned More Wood Last Winter (Q65)	# Obs	Yes	6	3	12	14	3	0	38
	# Obs	No	5	2	16	26	7	0	56
	# Obs	Unknown	0	0	1	1	0	0	2
	# Obs	N/A	75	16	32	61	18	1	203
	# Obs	All	86	21	61	102	28	1	299
	# Obs	All With	11	5	28	40	10	0	94
	% Obs	**Yes**	**54.5%**	**60.0%**	**42.9%**	**35.0%**	**30.0%**	**0.0%**	**40.4%**
	% Obs	**No**	**45.5%**	**40.0%**	**57.1%**	**65.0%**	**70.0%**	**0.0%**	**59.6%**
	% Obs	**All With**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**0.0%**	**100.0%**
Fuel Price to Stop Using Wood, $/gal (Q66)	**Mean**	**Per Equipped Household**	**$1.46**	**$1.95**	**$1.74**	**$1.78**	**$2.00**	**$0.00**	**$1.74**
	Minimum	**Per Equipped Household**	**$0.50**	**$1.95**	**$0.85**	**$0.00**	**$1.00**	**$0.00**	**$0.00**
	Maximum	**Per Equipped Household**	**$2.00**	**$1.95**	**$3.51**	**$5.00**	**$3.00**	**$0.00**	**$5.00**
	Std Dev	**Per Equipped Household**	**$0.61**	**#DIV/0!**	**$0.79**	**$1.27**	**$1.00**	**$0.00**	**$1.04**
Wood Stove/Insert Seasoning (months) (Q16)	**Average**	**Month**	**13.0**	**15.0**	**15.3**	**16.5**	**8.3**	**#DIV/0!**	**14.4**
Wood Stove/Insert Moisture Content (%) (Q17)	**% Obs**		**1.00%**	**#DIV/0!**	**7.25%**	**8.33%**	**11.25%**	**#DIV/0!**	**7.88%**

Report No. SR2012-10-10

CMAQ Support for Expanded $PM_{2.5}$ Monitoring in Fairbanks, Alaska

prepared for:

Fairbanks North Star Borough

October 17, 2012

prepared by:

Sierra Research, Inc.
1801 J Street
Sacramento, California 95811
(916) 444-6666

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CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska

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1. INTRODUCTION AND SUMMARY

In December 2008, Fairbanks was designated by the U.S. Environmental Protection Agency (EPA) as a $PM_{2.5}$[*] nonattainment area (NA). When that designation was later formalized by notice in the Federal Register, the State of Alaska was placed on a three-year statutory timetable for preparing and submitting a State Implementation Plan (SIP) to achieve and maintain the national ambient air quality standard for $PM_{2.5}$. However, only limited and partially conflicting information was then available on the sources of the problem.

Early studies had identified wood burning, on-road vehicles, and other source categories as the likely contributors of primary, i.e. directly-emitted $PM_{2.5}$ during air pollution episodes. However, at that time the contribution of each source was not well understood, and there was insufficient information available to understand and quantify the formation mechanisms and contribution of secondary $PM_{2.5}$, i.e., the formation of $PM_{2.5}$ in the atmosphere due to emissions of precursor gases including: sulfur dioxide (SO_2), nitrogen oxides (NOx), ammonia (NH_3), and volatile organic compounds (VOC). A more scientifically-based and technically sound understanding was needed to develop an effective and efficient emissions control strategy for Alaska's Fairbanks $PM_{2.5}$ SIP.

A 2007 review[1,†] of studies and data relevant to $PM_{2.5}$ emissions in and around Fairbanks documented the most critical knowledge gaps in understanding the magnitude, causes, and potential solutions to the problem of elevated winter-time $PM_{2.5}$ concentrations in and around Fairbanks, and helped guide the Alaska Department of Environmental Conservation's (ADEC) research strategies. In the summer of 2008, FNSB hosted an Air Quality Symposium[2] on the status of efforts to investigate and understand the causes of the elevated $PM_{2.5}$. The goal was to bring together members of the community and people with experience in $PM_{2.5}$ measurement, analysis, and modeling to engage in thoughtful discussions about the science governing $PM_{2.5}$ formation during winter months in Fairbanks. Through these and other early efforts, the need for a number of supplemental monitoring studies was recognized, and the Borough identified the particular need for a "Saturation Study" of $PM_{2.5}$. That Study, which was to provide more intensive monitoring, was approved for funding by the Congestion Management for Air Quality (CMAQ) program.

[*] "$PM_{2.5}$" refers to fine particles having an aerodynamic diameter smaller than 2.5 microns.
[†] Numeric superscripts denote references provided in Section 5.

The expanded monitoring study discussed herein was conducted intensively in the winters of 2008-09, 2009-10, and 2010-11, although some elements commenced earlier (as pilot studies) and/or continued beyond the intensive study time window.

As originally conceived, the Saturation Study was to rely in part on the use of relatively low-cost (~$5,000 each) used "minivol" samplers that were assumed to be available from ADEC, and on the purchase of a new Aerosol Particle Sizer (APS) to be installed in a mobile sampling platform, e.g. a "sniffer" vehicle.[3] However, the minivol-based approach was found to be problematic, in part due to minivol unavailability. Furthermore, as discussed elsewhere, [3] a suitable APS that met project needs for both on-the-fly mobile operation and affordability could not be identified. In place of both of these contemplated study elements, and to complement other aspects of the Borough's stationary and mobile monitoring efforts, a series of other $PM_{2.5}$ measurement efforts were undertaken, which may be more aptly characterized as "Expanded Monitoring" rather than Saturation Monitoring. These efforts included the following:

- Expanded SASS[*] monitoring (Spiral Ambient Speciation Sampler) – measurements of the elemental and chemical composition of aerosol captured on 24-hour average filters
- PILS (Particle Into Liquid Sampler[†]) – high time resolution (1-hour) sampling of ionic composition of ambient aerosol
- TEOM/FDMS (Tapered Element Oscillating Microbalance/Filter Dynamic Measurement System) – very high time resolution (minutes) of FRM-like measurements of $PM_{2.5}$ mass
- Aethelometers[‡] – operational measurements of black carbon (which is currently used as a surrogate for elemental carbon for which there is no universally accepted standard measurement method)
- ^{14}C analysis – limited analysis[§] of the isotopic composition of carbon in SASS aerosol samples; this analysis provides an indication of the relative fractions of "fossil carbon" (from burning oil, coal, and other fossil fuels) vs. "contemporary carbon" from burning wood and other biofuels
- Levoglucosan – limited analysis[4] for specific chemical markers of wood burning and other fuel burning in SASS samples of ambient $PM_{2.5}$

The individual study elements are described later in this report. Results from the expanded sampling are summarized below.

[*] MetOne, Grants Pass, OR.
[†] Using PILS-FC and Sunset Labs (Forest Grove, OR) field instrument.
[‡] Analysis of aethelometer data is in progress at Washington University, St. Louis at the time of this writing.
[§] ^{14}C analysis was performed at the University of Arizona's Accelerator Mass Spectrometry Laboratory under contract to the University of Montana.

1.1 Summary of Results from the Expanded Sampling Program

The key point to understand about the expanded sampling program is that no single measurement study element, by itself, was expected to or found to adequately define the problem, guide strategy development, and document the technical basis for the SIP. Rather, an integrated "weight-of-evidence" study approach has been used, consistent with EPA SIP guidance, to help elucidate and document the sources of the $PM_{2.5}$ exceedances in the Fairbanks NA area. More specifically, the above study elements provided essential input and validation data for the several modeling studies that serve as the basis for SIP strategy development. Summarized below are the main contributions from each of the expanded study elements. More detailed SASS and other measurement results and modeling results are presented in Section 3 of this report.

1. Speciated SASS monitoring of $PM_{2.5}$ elemental and chemical composition directly supported the chemical mass balance-based (CMB) source apportionment study by the University of Montana[5] and the Positive Matrix Factorization (PMF)/UNMIX study by Sierra Research,[6] each of which pinpointed and documented wood burning as the primary source of ambient $PM_{2.5}$. SASS sampling data also helped provide validation for the bottom up emissions inventory and Community Scale Model of Air Quality (CSM)[*] and dispersion modeling that was used to develop and evaluate alternative emission control strategies. This was particularly important for measurement of the individual chemical components of $PM_{2.5}$ (sulfates, nitrates, ammonium, and organic compounds), which are required by EPA to be considered in the SIP analysis.

2. PILS analysis performed a similar type of function to SASS, but at a much finer time resolution (on the order of 1 hour rather than 24 hours for SASS and FRM sampling), thereby providing important insights about diurnal variations in chemical species that are obscured by the integrated filter data. Although a final data analysis report is not yet available, preliminary results[7] showed that $PM_{2.5}$ mass is mainly from wood burning, and a small fraction is from coal, oil, and other sources.

3. TEOM/FDMS sampling data were used to provide insight into the diurnal variation of $PM_{2.5}$, which helped to confirm wood burning as a major contributor. They were also used, along with BAM data calibrated to (filter-based) FRM sampling, to provide high time resolution $PM_{2.5}$ measurements for calibration of the Borough's mobile sampling.[8] That sampling greatly expanded the spatial resolution of $PM_{2.5}$ measurements, thus helping to define the extent of the fine particle problem and the magnitude and locations of $PM_{2.5}$ "hot spots."[9]

4. The University of Arizona's ^{14}C analysis of SASS $PM_{2.5}$ samples provided data confirming that wood smoke is a large contributor to the overall $PM_{2.5}$ mass in the Fairbanks.[5]

[*] The Community Scale Model for Air Quality is commonly known by the acronym, "CMAQ" but, in order to avoid confusion in this report, we use "CSM" to refer to the Community Scale Model and "CMAQ" to refer to the Congestion Management for Air Quality Program.

5. The University of Montana's chemical analysis of SASS $PM_{2.5}$ samples documented the presence of levoglucosan in Fairbanks $PM_{2.5}$ at elevated levels compared to other cities and concluded that wood smoke is a substantial contributor to ambient $PM_{2.5}$ in Fairbanks in winter.[4]

6. The finer temporal, spatial, and composition-resolved measurements outlined above are all contributors to validation of the CSM dispersion modeling* for total $PM_{2.5}$ mass and/or for the mass of the major chemical constituents of $PM_{2.5}$, and they are significant contributors to the " weight-of-evidence" analysis and documentation for the Alaska $PM_{2.5}$ SIP.

Section 2 of this report provides an overview of the methods and data collection for each of the above elements of the Expanded Monitoring study. Section 3 presents a summary of results from the Expanded Monitoring Program. Section 4 documents CMAQ's critically important contributions to each of the Expanded Monitoring Study elements. Finally, Section 5 highlights the significance of the Study results for SIP development and support.

###

* CMAQ modeling work is in progress at Sierra Research at the time of this writing.

2. METHODS AND DATA COLLECTION FOR THE EXPANDED MONITORING STUDY

2.1 Scope of the Expanded Monitoring Network

By 2007, FNSB had operated an air quality monitoring station at the Downtown State Office Building for more than twenty years. The site was equipped with two Federal Reference Method $PM_{2.5}$ samplers (a primary sampler and a secondary, collocated sampler), along with a beta attenuation monitor (BAM) to provide hourly measurements. Several additional samplers were added in 2007 (see Table 2-1,[*] below).

Beginning in the winter of 2007-08, FNSB, with major CMAQ support, FNSB and others conducted greatly expanded stationary monitoring (see Table 2-2,[*] below) and mobile monitoring[10,3] of aerometric concentrations of $PM_{2.5}$ and other pollutants, as well as selected meteorological parameters. The main purposes of this monitoring, continued for 3 years (more, in some cases), was to help define the extent of the wintertime $PM_{2.5}$ problem and to better understand the sources that cause it.[11] Emissions measurement studies of the suspected major sources were also carried out in the same time frame under CMAQ, ADEC, and FNSB sponsorship, and are the subjects of two other companion CMAQ reports[12,13] to this one.

The next Section discusses operation of each element of the expanded stationary monitoring network.

2.2 Operation of the Expanded Monitoring Network

2.2.1 SASS Monitoring

Beginning in 2008, $PM_{2.5}$ sampling was conducted every third day at the Downtown (State Office Building) Monitor, in North Pole, at the Borough Transportation Department on Peger Road, and at various sites using the Borough's Relocatable Air Monitoring System (RAMS). The fixed site monitoring locations are shown in Figures 2-1, and the relocatable (RAMS) monitoring sites are shown in Figure 2-2[14] and described in a companion CMAQ report to this one.[3]

Sampling in Fairbanks at the four sites shown included a SASS sampler, which collected 24-hour integrated samples on Teflon, nylon, and quartz filters. The filters were analyzed

[*] Adapted from information provided by FNSB staff.

Table 2-1
Borough PM Monitoring Prior to the Expanded Monitoring Program

2005

State Office Building
FRM
FRM (Colocated)
BAM

2006

State Office Building
FRM
FRM (Colocated)
BAM

2007

State Office Building	Peger Road		RAMS		Nordale School		University Park School
FRM	FRM	Begin 9/6	FRM		FRM	Begin 10/3	FRM
FRM (colocated)	Aethalometer		CO	11/07-	TEOM FDMS	Begin 9/18	TEOM FDMS
	BAM	Begin 11/14			Aethalometer	Begin 7/1	Aethalometer
					MET	Begin 9/6	

Table 2-2
Borough Monitoring During and Following the Expanded Monitoring Program

2008

State Office Building		Peger Road		Nordale School		Sadler's Parking		North Pole	
FRM	Prior	FRM	Begin 10/12	FRM	In Operation	FRM	beg 10/3	FRM	Begin 12/26
FRM (colocated)	Prior	Aethalometer		TEOM FDMS	In Operation	TEOM FDMS	beg 6/24	Aethalometer	Begin 12/19
SASS	Prior	TEOM		Aethalometer	In Operation	Aethalometer	beg 6/28		
BAM	Prior	MET	Begin 10/22	MET	Begin 10/31	SO2	beg 7/1		
		BAM				NO/NO2/NOX	beg 7/31		

2009

State Office Building		Peger Road		RAMS		Nordale School		Sadler's Parking		North Pole		Grassy Knoll	
FRM	In Operation	FRM		FRM		FRM	Thru 4/7	FRM	thru 4/7	FRM	In Operation	FRM	Begin 10/31
FRM (colocated)	In Operation	TEOM	Begin 1/9	BAM		TEOM FDMS	Thru 03/31	TEOM FDMS	thru 4/24	TEOM FDMS	Begin 1/13	TEOM FDMS	Begin 11/9
BAM	In Operation	Aethalometer	Begin 11/13	CO		Aethalometer	Thru 4/16	Aethalometer	thru 8/25	Aethalometer	In Operation	Aethalometer	Begin 10/29
SASS	In Operation	SASS	Begin 11/23	SASS		MET	Thru 3/31	SO2	thru 4/15	MET	Begin 11/17		
BAM FEM		MET	Thru 3/31	MET				NO/NO2/NOX	thru 4/15	SASS	Begin 1/25		

SOB BAM becomes FEM 11/24/09. PEGER BAM becomes FEM 12/7/09.

2010

State Office Building		Peger Road		RAMS		North Pole		Grassy Knoll	
FRM	In Operation	FRM		FRM		FRM	In Operation	FRM	thru 12/31
FRM (colocated)	In Operation	TEOM		BAM FEM PM25		TEOM FDMS	In Operation	TEOM FDMS	In Operation
BAM	In Operation	Aethalometer		CO		Aethalometer	In Operation	Aethalometer	In Operation
SASS	In Operation	SASS		MET		SASS			
URG	In Operation	MET							
		BAM FEM	Thru 5/19	RAMS BAM becomes FEM 11/4/10.					
		BAM							

2011

State Office Building		Peger Road		RAMS		New Trailer		North Pole		NCORE	
FRM	In Operation	FRM		FRM	In Operation	FRM		FRM	In Operation	FRM	Begin 1/3
FRM (colocated)	In Operation	TEOM FDMS	Begin 5/6	BAM FEM PM25	In Operation	TEOM FDMS		TEOM FDMS	In Operation	BAM FEM PM10	Begin 2/16
BAM FEM PM25	In Operation	BAM FEM PM25		CO	Seasonal	BAM		Aethalometer	In Operation	BAM FEM PM25	Begin 2/16
SASS	In Operation	Aethalometer	In Operation	MET		Aethalometer		SASS		Aethalometer	thru 1/24/11
URG	In Operation	MET	In Operation			MET		MET	In Operation	CO	Not Installed
		TEOM	Thru 5/6							SO2	Not Installed
										NO/NO2/Nox	Not Installed
										NH3	Not Installed
										SASS	Not Installed
										TEOM FDMS	thru 3/25/11

Figure 2-1
Location of Fixed Site $PM_{2.5}$ Monitors in the Fairbanks NA Area

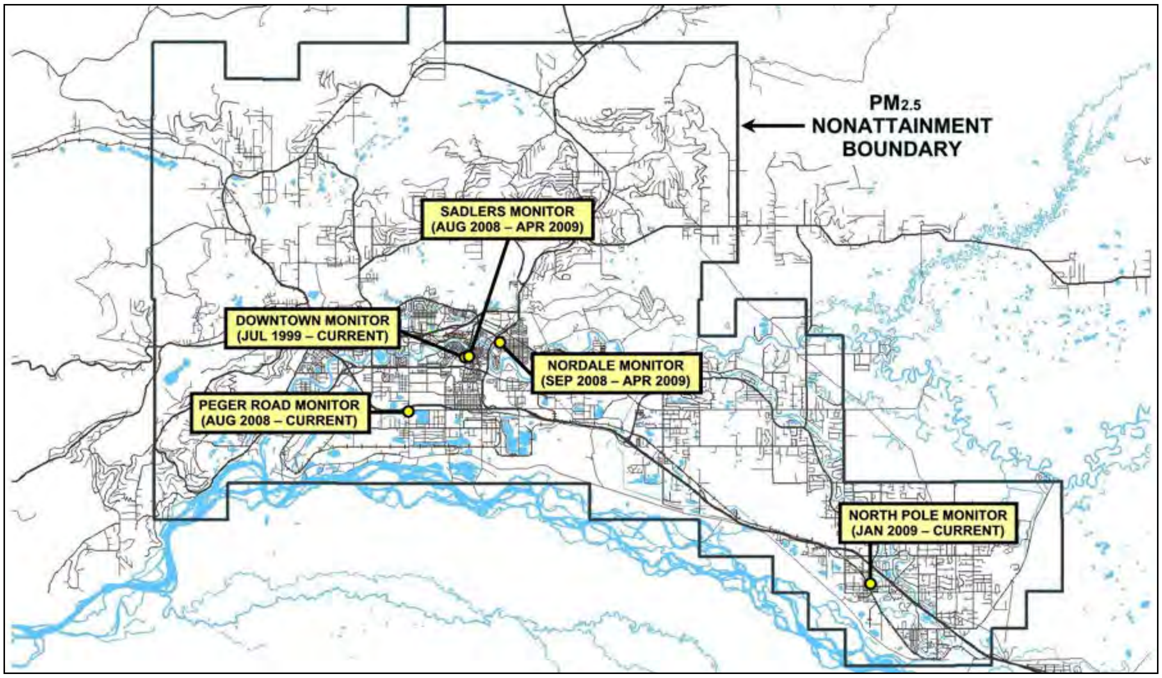
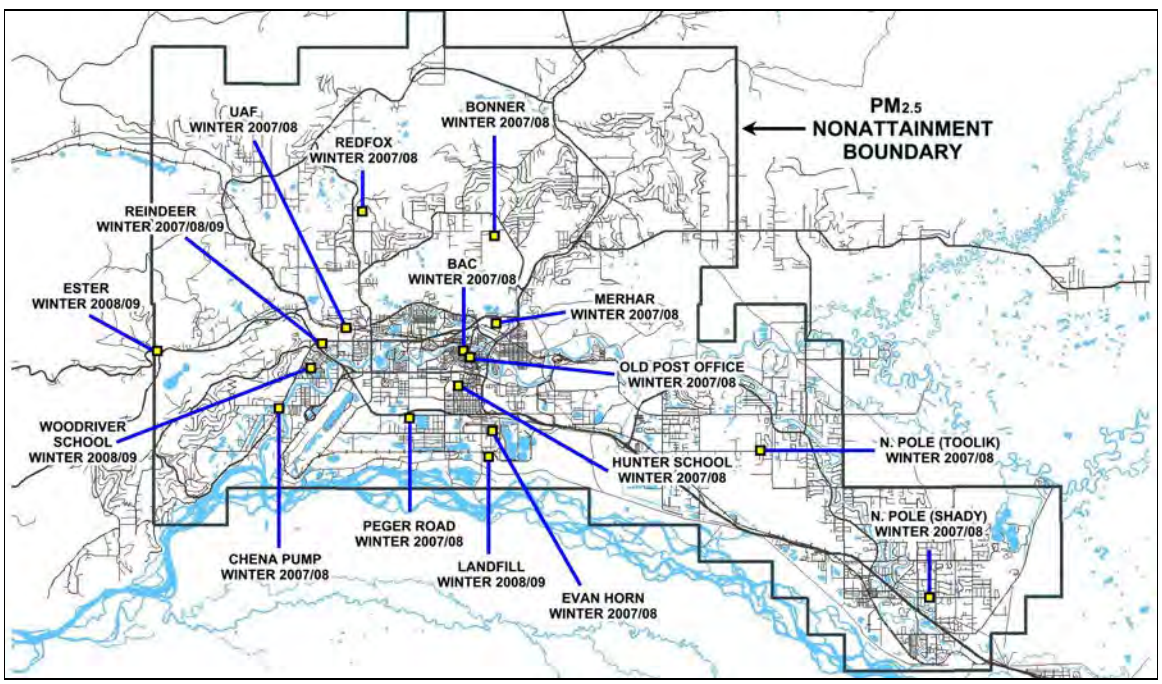


Figure 2-2
Location of Temporary Monitoring Sites in Fairbanks Using the RAMS Trailer



by Research Triangle Institute (except for ^{14}C and chemical wood smoke markers, which were analyzed elsewhere, as noted earlier). Quality Assurance/Quality Control for the program is described elsewhere.[5] Teflon filters were analyzed for total mass loading and then, by x-ray fluorescence, for mass concentration of 33 elements. Nylon filters were analyzed for concentrations of relevant ions (sulfate, nitrate, ammonium, etc.) by ion chromatography. Quartz filters were analyzed for organic and elemental carbon by Thermal Optical Transmittance. Selected results from this and other expanded monitoring elements are summarized in Section 3.

2.2.2 Particle into Liquid Sampling

PILS[7] sampling (not listed in the Tables) involved the collection of hourly samples that were frozen in vials, diluted, and later analyzed offline to provide measurements of 15 ions. Organic carbon (OC) and elemental carbon (EC) were analyzed immediately using Sunset Labs thermograms. Elemental analysis was also provided.

The PILS sampling, which was housed in DEC trailer, was conducted and apparently valid data were collected in the period from March 1-17, 2011. Sampling was continued for several months in the winter of 2011-12 but using the Borough's RAMS trailer and a semi-continuous x-ray fluorescence (XRF) technique to measure a suite of elements. As of this writing, the only available data are those from March 2011 ("barely validated; not to be cited").

2.2.3 TEOM/FDMS

TEOM/FDMS monitoring of $PM_{2.5}$ began in 2007 with limited-term monitoring at Nordale and University Park Schools. This provided insight into the diurnal variation of $PM_{2.5}$, thus helping to understand the level of exposure of children during times of activity. (FRM measurements were also made at these sites, but provided only 24-hour average concentrations.)

As an important side benefit, and as part of the Borough's instrumented vehicle monitoring study in the winter of 2008-09,[15] the finely time-resolved TEOM/FDMS measurements of $PM_{2.5}$ at Nordale School were calibrated to the FRM monitor at the same site and then used, during a portion of each drive, to calibrate the $PM_{2.5}$ sampling instrument in the vehicle.

2.2.4 Aethelometer Measurements

Monitoring of ambient concentrations of black carbon in $PM_{2.5}$ by use of aethelometer commenced in 2007 at the two schools, and at the Borough's Peger Road Transportation Department monitoring site, which was also equipped with an FRM $PM_{2.5}$ monitor and a BAM. A fourth aethelometer was added in 2008 at a new van-based monitoring site in Sadler's Parking lot. The Sadlers' site was specifically chosen for its proximity to the long-term monitoring site at the downtown State Office Building in order to help understand whether the rooftop location of the latter had a significant effect on measured $PM_{2.5}$ concentrations.*

2.2.5 ^{14}C and Levoglucosan Measurements

^{14}C measurements, as well as measurements of levoglucosan and selected chemical compounds, were made by including an additional quartz filter at each of the SASS monitoring sites. Because the ^{14}C analysis is relatively expensive, only a limited number of filters were analyzed, totaling 45 site-days for the four SASS monitoring sites† over the 3-winter period. Filters of interest were cut in two, with one half sent to the University of Arizona for ^{14}C analysis, and the other half analyzed by Gas Chromatography/Mass Spectrometry at the University of Montana. The latter were analyzed for levoglucosan and a number of other potentially useful marker compounds.

2.3 Analysis of Data from the Expanded Monitoring Network

Quality Assurance/Quality Control (QA/QC) reports on air quality monitoring and reports on the data itself are prepared by FNSB and DEC staffs, and the data are reported to the USEPA by DEC. Supplemental analysis of data from the Expanded Monitoring Network, and from long-term monitoring, has been provided through both one-time study reports and a series of technical memoranda[16, 11, 15, 17, 18, 19] and special reports. Selected results from the monitoring, taken from these and other sources, are presented in Section 3.

###

* A second reason for the using the nearby site was that space and power were limited at the roof-level downtown monitoring site, which prevented siting more equipment there. In the longer term, the Borough addressed this problem by investigating and then installing a monitoring site (“NCORE”) at a nearby location known as “Grassy Knoll.”

† Following the convention in Ward’s 2012 Source Apportionment Study, here we count the RAMS trailer as one site (it contributed only 2 site-days in February 2009 to the total of 45 listed).

3. RESULTS FROM THE EXPANDED MONITORING STUDY

This section is intended to highlight selected results from each element of the Borough's CMAQ-sponsored Expanded Monitoring Study.

3.1 Expanded SASS Monitoring

SASS monitoring was probably the most ambitious, labor-intensive, and costly of the expanded monitoring elements, but it was also among the most useful, providing important input to all four of the main modeling analyses used for the SIP. Highlighted here are modeling results that were enabled by the SASS monitoring.

For source apportionment, i.e. determination of how much of the $PM_{2.5}$ problem during winter days was caused by each of the various sources, measurement data from SASS (and other sources) were relied upon by the University of Montana (U of M), who used it to conduct Chemical Mass Balance modeling. U of M's analysis, found that wood smoke was the largest source of $PM_{2.5}$ in both Fairbanks and North Pole in all three of the winter seasons examined. Figures 3-1 and 3-2, taken from the U of M report, show a small portion of U of M's CMB results reflected in source attribution pie charts for the Fairbanks and North Pole monitoring sites, respectively. The results in Figure 3-1 reflect (along with other data) all available SASS measurements from the downtown Fairbanks State Office Building monitoring site from November 8, 2008 through April 7, 2009. Results in Figure 3-2 are from the North Pole SASS data from January 25, 2009[*] to April 7, 2009. Absent SASS data, this type of definitive CMB identification of wood smoke as the primary source of wintertime $PM_{2.5}$ in the two cities in the NA area, and the quantification of the wood smoke contribution at each community's air monitoring site, would not have been possible.

In addition to such seasonal CMB modeling comparisons, the temporal changes (or lack of changes) in $PM_{2.5}$ composition over shorter time periods can be indicative of source impacts during episodes and even during individual days. The $PM_{2.5}$ episode depicted in the SASS data of Figure 3-3, for example, suggests that composition and source mix were substantially similar immediately before (11/04/08) and during most of this relatively mild temperature extended duration episode. This is important to know because it allows focusing on the control strategy and SIP development on those elements contributing the most to the problem.

[*] The North Pole SASS monitoring was started later than the at the Fairbanks downtown monitoring site.

Figure 3-1
University of Montana's[5] Fairbanks CMB Results, Winter 2008-09
(PRELIMINARY RESULTS – DO NOT CITE OR QUOTE)

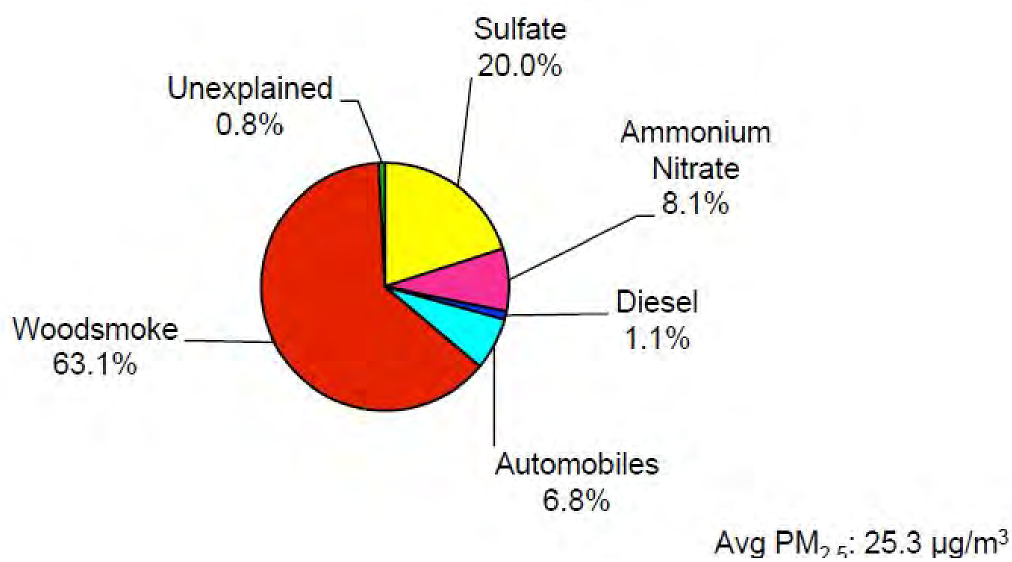


Figure 3-2
University of Montana's[5] North Pole CMB Results, Winter 2008-09
(PRELIMINARY RESULTS – DO NOT CITE OR QUOTE)

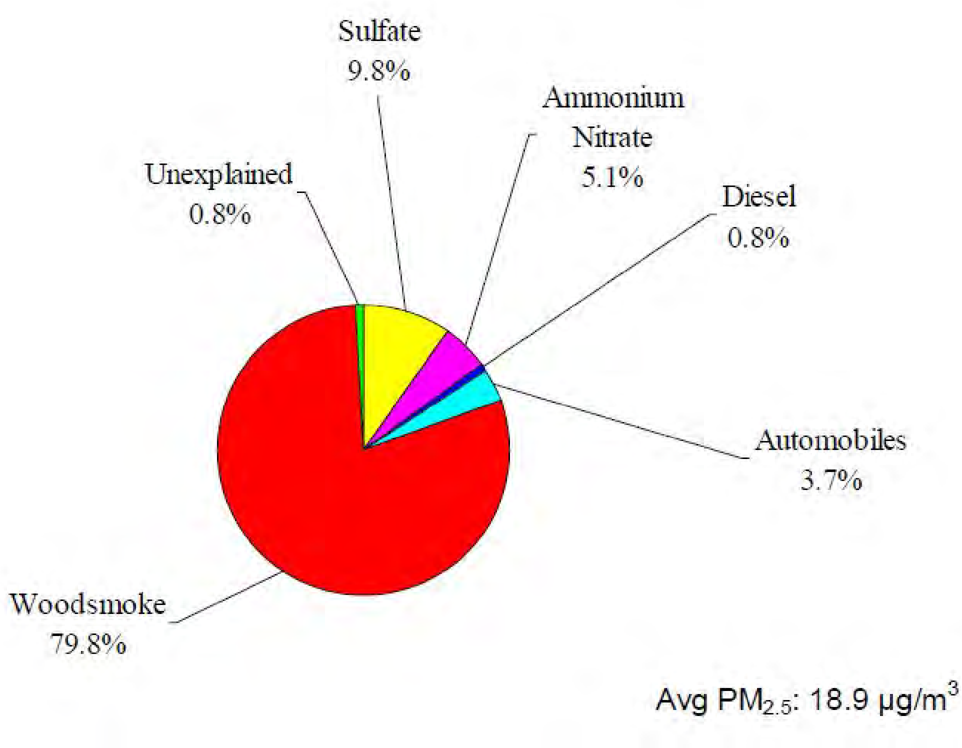


Figure 3-3
Measured $PM_{2.5}$ Component Trends for the November 2008 $PM_{2.5}$ Episode[20]
(PRELIMINARY RESULTS – DO NOT CITE OR QUOTE)

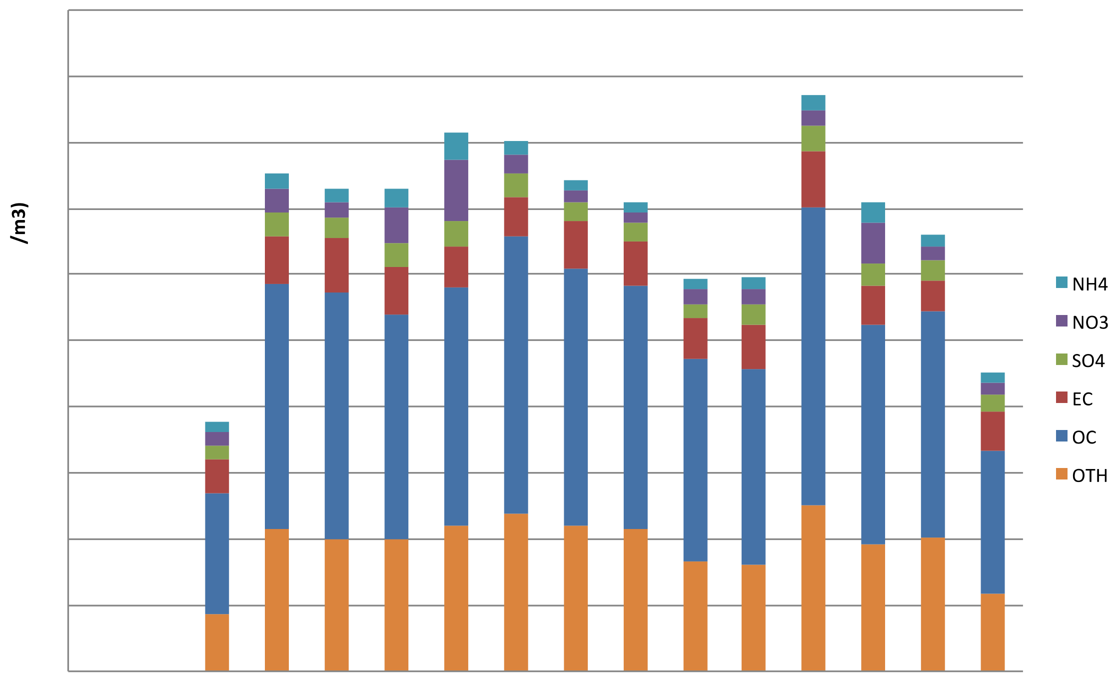
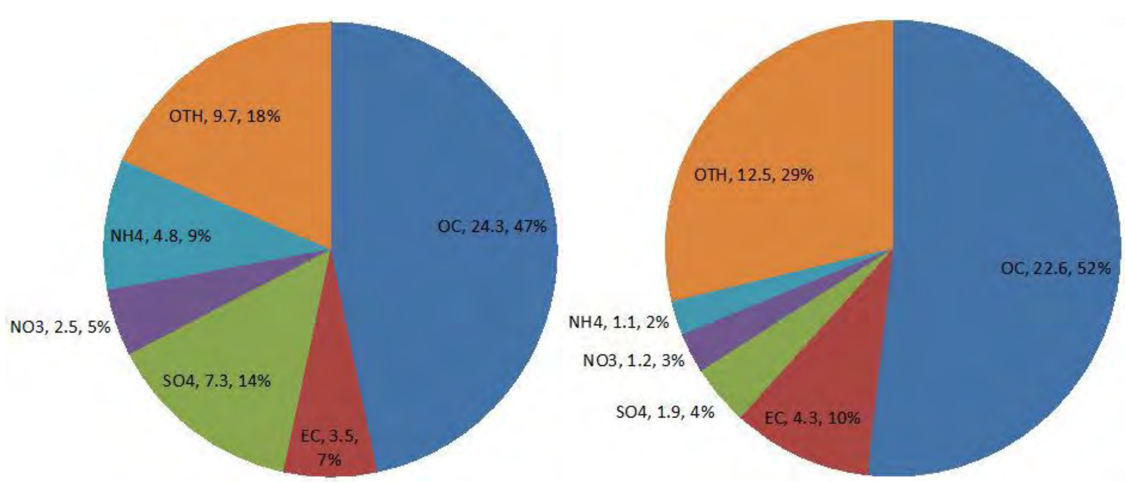


Figure 3-4
Comparison of Observed (Left) and Modeled (Right) Speciation for 11/14/08[20]
(PRELIMINARY RESULTS – DO NOT CITE OR QUOTE)



In order to know more about which source(s) contribute, and by how much, at locations throughout the NA area, including locations that have not been monitored, requires a dispersion model. In addition, EPA SIP guidance[21,22] requires assessment of percentage reductions for individual chemical species that contribute to the total $PM_{2.5}$ mass during design day episodes.

For the Alaska SIP, dispersion modeling is being conducted by DEC, the University of Alaska at Fairbanks, and Sierra Research. To validate these dispersion modeling results, which provide temporally and spatially distributed predicted concentrations of the chemically speciated constituents of $PM_{2.5}$, requires the SASS measurements.

The results from one sample comparison of measured and modeled data (many such comparisons, in diverse forms, have been performed) is shown in Figure 3-4. For the case shown, the predicted (right side pie) values of NH_4 and SO_4 (2% and 4%, respectively) were seen to be much lower than the corresponding observed values (9% and 14%) which, if confirmed in final results, has important implications for how the modeling results must be scaled before they are used to evaluate emission control strategies.

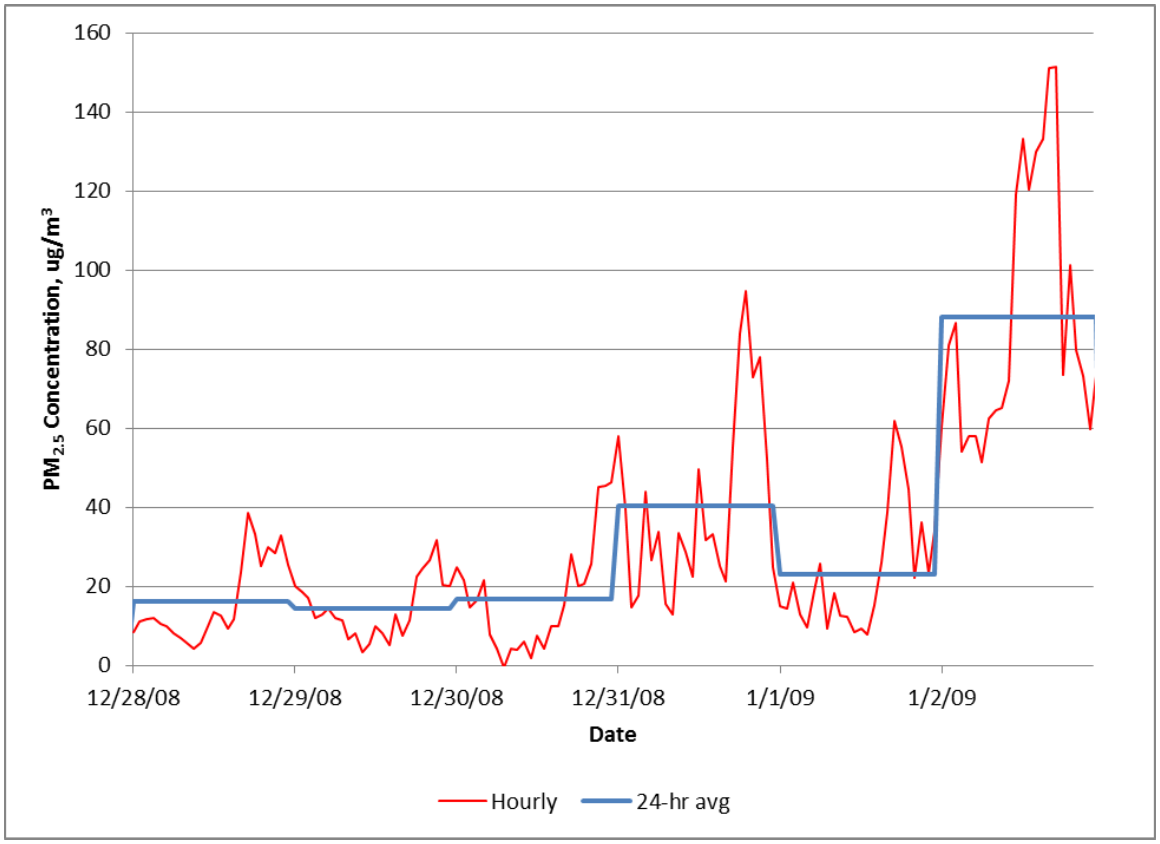
As for EPA's requirement of assessing percentage reductions for individual species, an analysis has been performed by Robert Crawford and Robert Dulla[23,24] which explains the $PM_{2.5}$ masses recorded at the downtown monitoring site as a function of source emissions inventories and the meteorology governing trapping conditions. Ongoing work intends to extend that analysis to comply with EPA's SIP guidance by calculating the required Relative Reduction Factors (RRFs) of each of the $PM_{2.5}$ constituent species.

3.2 TEOM/FDMS

TEOM/FDMS provides the valuable benefit of providing short-term (hourly) measurements that, when averaged, are comparable to filter-based (integrated) 24-hour FRM measurements. In this way, they complement the FRM measurements but can reveal fine temporal structure that is unavailable from 24-hour filter-based measurements.

Early in the Expanded Study, analysis of available hourly BAM data from downtown monitor by DEC staff showed evening peaks in $PM_{2.5}$, which were consistent in timing[25] with evening residential wood burning. TEOM/FDMS measurements provided a means to confirm the non-standard BAM measurement results with a measurement method that could be directly reconciled with the 24-hour average federal measurement method. An example of the of the TEOM/FDMS data, showing both 24-hour average and hourly measurements is shown in Figure 3-5, below. As with DEC's observation of hourly BAM measurements, TEOM/FDMS values likewise peaked in the evening hours, consistent with evening wood burning. By itself, neither fact confirms wood burning as the source of the $PM_{2.5}$ peaks in data sample shown, but the timing of both BAM and TEOM/FDMS measurement peaks is consistent with wood burning as a major contributor (in contrast, for example, to a hypothetical on-road source which might be expected to show a bi-modal distribution centered on morning and afternoon peak traffic hours.)

Figure 3-5
Hourly and 24-hour Averaged PM2.5 Concentrations Measured by TEOM/FDMS at the Nordale Elementary School as part of the Expanded Monitoring Program26 (PRELIMINARY DATA)



Source: FNSB

3.3 ^{14}C and Levoglucosan Measurements

Results from the sampling and analysis of ^{14}C and levoglucosan are detailed in reports from the University of Montana.[5, 4, 27] While limited in number, results for all of the samples analyzed for ^{14}C showed that, "32 to 66% of the measured ambient $PM_{2.5}$ came from a new carbon, or a wood smoke source." Ward[5] concluded as follows:

> *When we compare the percent wood smoke component identified by the CMB model to the wood smoke identified by the ^{14}C analysis, it appears the CMB model (using the EPA profiles and not the OMNI profiles) frequently over-reports the wood smoke contribution. The ^{14}C results confirm that wood smoke is a large contributor to the overall $PM_{2.5}$ mass in the Fairbanks airshed.*

3.4 Other

For PILS and aethelometer measurements, no analysis of results was available at time of this writing.

###

4. CMAQ CONTRIBUTIONS TO THE EXPANDED MONITORING STUDY

The expanded monitoring network that was outlined in the previous Sections has required substantial labor by Borough staff as well as materiel support, neither of which would have been possible without CMAQ support.

Borough staff, led by Dr. Jim Conner, designed and implemented the monitoring network expansions described in the previous Sections. He and his staff detailed monitoring needs, chose monitoring sites, arranged shelter and power, selected and installed instruments, serviced them both regularly (routine maintenance, filter changing, data retrieval, etc.) and irregularly (repairs), maintained proper custody and handling of samples, and performed all QA/CC and reporting. Supported instruments included a wide range of types and demands, some of which had never before been exposed on a long-term basis to Alaska winter conditions and had to be upgraded or replaced.

Borough air quality staff who contributed to the expanded monitoring effort and who were supported in whole or in part though CMAQ funding, included those listed below.

Jeremy Bahr
Adelia Falk
Steve Gano
Dan Gavoni
Ron Lovell
James McCormick
Karen Remick
Nicole Swensgard
Kelly Shaw
Paul Simpson
Todd Thompson

###

5. SIGNIFICANCE OF THE SUBJECT STUDY

Results from the Expanded Monitoring Study are the basis for the Alaskan $PM_{2.5}$ SIP.

SASS monitoring from the expanded study permitted the source apportionment study which demonstrates and documents that residential wood-burning is the major source of directly emitted $PM_{2.5}$. ^{14}C and levoglucosan measurements confirm that through independent sample analysis and modeling.

SASS monitoring is the basis for validating the Community Scale Model of Air Quality, which is being used to develop and evaluate emission reduction strategies. SASS also provided the input to drive positive matrix factorization, UNMIX, and principal component analysis modeling, each of which provides different insight into the relationship between emission sources and ambient measurements.

Ambient concentrations of the major $PM_{2.5}$ ions, aside from their use as inputs that drive models and a source of validation to check models, must be reduced in order to demonstrate an approvable SIP consistent with USEPA SIP Guidance. For Fairbanks, SASS measurements provide the only source of this data.

Taken together, the above elements, all of which derive from the Expanded Monitoring Study either directly or through supported modeling, provide the primary weight of evidence for the Alaska $PM_{2.5}$ SIP.

Absent SASS and other Expanded Monitoring Study elements, there would be no compelling evidence demonstrating that residential wood burning is the primary source or even a major source of Fairbanks winter $PM_{2.5}$ exceedances, no reliable quantification of the effect of that wood burning on ambient $PM_{2.5}$ concentrations during $PM_{2.5}$ exceedance periods, and no credible technical basis for developing and evaluating alternative SIP strategies. In short, there would be no rational basis for a weight of evidence demonstration for the Alaska $PM_{2.5}$ SIP.

###

6. REFERENCES

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2. See, for example, "Fairbanks Air Quality Symposium Summary," available here: http://co.fairbanks.ak.us/airquality/Docs/Symposium_Summary.pdf

3. "CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska" prepared for Fairbanks North Star Borough by Sierra Research, October 17, 2012.

4. Palmer, Christopher, "Fairbanks, Alaska $PM_{2.5}$ Organic Composition and Source Apportionment Research Study," University of Montana, August 10, 2012.

5. Ward, Tony, "The Fairbanks, Alaska, $PM_{2.5}$ Source Apportionment Research Study," prepared by the University of Montana, July 23, 2012.

6. Memorandum to Alice Edwards from Wei Liu and Bob Dulla, "Comparison of UNMIX and PMF Analysis of Fairbanks Speciation Data," November 21, 2008.

7. Peltier, Rick, "PM Composition in Fairbanks," presented at the Fairbanks air quality workshop, January 10-12, 2012.

8. Memorandum to Alice Edwards from Frank Di Genova and Robert Dulla, "Technical Report on the Instrumented Vehicle Monitoring Study," Contract No. 18-3001-20-9B, July 27, 2009.

9. See the companion CMAQ report, entitled, "CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska," prepared for Fairbanks North Star Borough by Sierra Research, October 17, 2012.

10. Memorandum to Alice Edwards, from Frank Di Genova and Robert Dulla, "Data Analysis for Winter 2007-08 Neighborhood Characterization ("Sniffer Lite") Study," August 20, 2008.

11. Memorandum to Alice Edwards et al, from Craig Anderson, Robert Dulla and Frank Di Genova, "Fairbanks Neighborhood Characterization Study 2007-08, Analysis of Supplemental Data," July 30, 2010.

12. "CMAQ Support for Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks, Alaska," prepared for Fairbanks North Star Borough by Sierra Research, September 11, 2012.

13. "CMAQ Support for Space Heating Study in Fairbanks, Alaska," prepared for Fairbanks North Star Borough by Sierra Research, September 11, 2012.

14. Both figures and additional information about the expanded $PM_{2.5}$ monitoring program and other expanded Borough aerometric monitoring are available from "Fairbanks Air Quality Symposium Summary," prepared by Sierra Research, February 8, 2010.

15. Memorandum to Alice Edwards et al, from Frank Di Genova and Bob Dulla, "Technical Report on the Instrumented Vehicle Monitoring Study, Contract No. 18-3001-20-9B" (draft), July 27, 2009.

16. Memorandum to Alice Edwards, from Frank Di Genova and Bob Dulla, "Data Analysis for Winter 2007-08 Neighborhood Characterization ('Sniffer Lite') Study," August 20, 2008.

17. Memorandum to Cindy Heil, et al, from Craig Anderson and Bob Dulla, "Summary and Analysis of Fairbanks $PM_{2.5}$ Data for Winter 2009-2010" (draft), August 25, 2010.

18. Memorandum to Cindy Heil, et al, from Frank Di Genova and Bob Dulla, "Summary and Analysis of Fairbanks $PM_{2.5}$ Data for Winter 2010-2011," September 8, 2011.

19. "Measurement Results from Stationary and Mobile Monitoring (all data preliminary)," prepared by Sierra Research for the Fairbanks North Star Borough, February 2009.

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21. USEPA (2007): Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze, EPA-454/B-07-002, US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2007.

22. USEPA (2011): Attachment A and B. http://www.epa.gov/ttn/scram/guidance/guide/Update_to_the_24-hour_PM25_Modeled_Attainment_Test.pdf.

23. Crawford, Robert, "Principal Component Analysis: Inventory Insights and Speciated $PM_{2.5}$ Estimates," prepared by Rincon Ranch Consulting, presented at the Fairbanks Air Quality Workshop, January 11, 2012.

24. For additional information on the Principal Component Analysis-based approach, see: Crawford, Robert, and Dulla, Robert, "For Peer Review - Statistical Assessment of $PM_{2.5}$ and Meteorology in Fairbanks, Alaska," prepared for Alaska Department of Environmental Conservation by Rincon Ranch Consulting and Sierra Research, September 2011.

25. Personal communication by Sierra Research with Cindy Heil, DEC, February 25, 2008.

26. Preliminary data provided by FNSB, 2008.

27. Synthesis of woodsmoke estimates from the various analyses, Section 2, Apportioning $PM_{2.5}$ Woodsmoke using Radiocarbon Data (preliminary), prepared by Dr. Jay Turner, Washington University, St. Louis, 2012.

###

Report No. 2012-10-11

CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska

prepared for:

Fairbanks North Star Borough

October 17, 2012

prepared by:

Sierra Research, Inc.
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CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska

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1. SUMMARY

In December 2008, Fairbanks was designated by the U.S. Environmental Protection Agency (EPA) as a $PM_{2.5}$[*] nonattainment area. The designation was based largely upon the State's nonattainment recommendations to EPA, which were, necessarily, developed from temporal trends at a single monitoring site in downtown Fairbanks. At that time, very few other data were available on the spatial extent and variability of ambient $PM_{2.5}$ concentrations within and surrounding Fairbanks.

A 2007 review[1,†] of studies and data relevant to $PM_{2.5}$ emissions in and around Fairbanks cited the unknown areal extent of high $PM_{2.5}$ in the vicinity of Fairbanks, especially during the coldest times or when $PM_{2.5}$ exceeds 35 µg/m^3, as one of the most critical knowledge gaps in understanding the magnitude, causes, and potential solutions to the problem of elevated winter-time $PM_{2.5}$ concentrations in and around Fairbanks. Furthermore, it was unknown at the time whether $PM_{2.5}$ "hot spots" existed in populated areas, whether the Borough's downtown monitor was well-positioned to capture peak $PM_{2.5}$ concentrations, and whether otherwise suitable strategies to mitigate the peak measured concentration would also mitigate any peak concentrations at other unmeasured locations (which could, for example, be due to a different source mix). For these and other reasons, the review recommended a mobile areal $PM_{2.5}$ measurement ("sniffer")[‡] survey as its second-highest priority (after development of a temporally and spatially resolved emissions inventory of $PM_{2.5}$ and its precursors).

With support from the Congestion Mitigation and Air Quality Program (CMAQ) in 2008-2009, 2009-2010, and 2010-2011, Fairbanks North Star Borough (Borough) was able to conduct mobile monitoring to address these knowledge gaps. Named "the Neighborhood Characterization Study," the Borough's mobile monitoring relied on the use of a "sniffer" vehicle and RAMS[§] trailer measurements in the winter of 2008-2009 and annual neighborhood surveys in each of the following two winter seasons. Analysis of the resulting data has greatly improved understanding of the severity and spatial extent of the $PM_{2.5}$ nonattainment problem and has provided key insights and documentation into the causes and possible mitigation of the excess $PM_{2.5}$. Outlined below are findings

[*] "$PM_{2.5}$" refers to fine particles having an aerodynamic diameter smaller than 2.5 microns.
[†] Numeric superscripts denote references provided in Section 5.
[‡] "Sniffer" refers to a vehicle that is instrumented to sample outside air while driving and is able to perform on-the-fly ambient pollutant measurements every few seconds.
[§] "RAMS" refers to Relocatable Air Monitoring System, a moveable air monitoring trailer that uses standard Federal Reference Methods to measure criteria air pollutants and other non-standard methods for shorter time scales, specific chemical components, etc.

regarding spatial patterns in ambient $PM_{2.5}$ concentrations based on data from the sniffer studies.

1. The highest mobile monitoring concentrations of $PM_{2.5}$ were observed in the most densely populated areas (e.g., the cities of Fairbanks and North Pole).

2. Areas with low population density were generally found to have substantially lower concentrations (e.g., Goldstream Valley).

3. Concentrations, especially for daytime, along Airport Way (a busy arterial) were relatively high, but the source contribution was unclear, which underscores the need to better understand the motor vehicle contribution.

4. The highest mobile monitoring concentrations occurred from 4:00-6:00 pm, which was consistent with the downtown stationary monitor on high $PM_{2.5}$ days.

5. There were pockets of high concentrations that appeared to be located in neighborhoods that were older, had high levels of wood-burning, or were in areas of low elevation.*

6. Throughout the region, localized impacts from individual outdoor wood or coal boilers (OWBs/OCBs) could sometimes be identified in elevated $PM_{2.5}$ values, both for individual drives and in concentrations averaged over numerous drives.

7. No clear evidence was found for ground-level $PM_{2.5}$ impacts from large, elevated stationary sources (e.g., power plants).

8. No ($PM_{2.5}$) data were collected at Ft. Wainwright. Given the proximity and potential importance, monitoring should be conducted there.

9. Spatial monitoring helped to identify the spatial extent of the problem and identify likely sources, while ruling out other sources, and it helped to prioritize areas where data need to be collected to better characterize the activities that generate emissions.

The second element of the Neighborhood Characterization Study was the configuration and deployment of the RAMS trailer. Unlike the sniffer, the RAMS did not sample while moving; instead, it was operated only when stationary, usually for two to four weeks at a time at each sampling location. Importantly, the RAMS trailer utilized standard Federal Reference Methods (FRMs)† to measure $PM_{2.5}$. As a result, its measurements can be used to help fill spatial gaps in the Borough's limited permanent monitoring network without the expense of a permanent monitor. In the winter of 2009-2010, the highest single 24-hour concentration of $PM_{2.5}$ at any Borough monitoring site was 113.1 $\mu g/m^3$

* For more detail, see the results presented in Section 3 of this report.
† FRMs for $PM_{2.5}$ are not feasible for use in a moving vehicle like the sniffer.

and was measured by the RAMS trailer, confirming the capability of this monitoring tool to help identify hot spots and fill the gaps on stationary monitoring.[2]

The remainder of this report provides background and documentation on the CMAQ-sponsored Fairbanks sniffer and RAMS trailer studies, and discusses the importance of their measurements for helping to develop technically sound public health and air quality management strategies.

###

2. BACKGROUND

As of 2007, Fairbanks had been measuring $PM_{2.5}$ at its downtown monitor for more than 20 years. Those measurements show a distinct seasonal pattern of elevated concentrations during both summer and winter months. Large, uncontrollable wild fires are the principal cause of the elevated summer values. The causes of the elevated winter values are more complex and include severe meteorology (i.e., low wind speed, low mixing depth heights, and subarctic winter temperatures), which limits dispersion potential; the combustion of large volumes of fuel for space heating (primarily high sulfur distillate fuel oil, wood and relatively low sulfur, low BTU coal); and poorly understood atmospheric chemistry that promotes secondary particulate matter formation. Collectively, these factors have caused the Borough to routinely exceed the more stringent 35 $\mu g/m^3$ National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ that EPA established in 2006. As a result, Fairbanks has been designated as a $PM_{2.5}$ nonattainment area and Alaska has been required to develop and adopt a State Implementation Plan (SIP) to attain the $PM_{2.5}$ standard.

In the winter of 2006-2007, the Alaska Department of Environmental Conservation (ADEC), recognizing significant gaps in understanding of the $PM_{2.5}$ problem in Fairbanks, commissioned several exploratory studies of ambient and directly emitted $PM_{2.5}$. These studies were followed in 2007-2008 by a more systematic sniffer study and RAMS sampling, both of which are described in the remainder of this chapter.

2.1 Mobile $PM_{2.5}$ Sampling in 2006-2007

In the winter of 2006-2007, ADEC sponsored on-road and dynamometer-based surveys of $PM_{2.5}$ in Fairbanks. Both study elements relied upon the use of measurement equipment that was on-hand or readily available (borrowed, as-is) at the time. The main objective of both pilot study elements was to help select, configure, and evaluate equipment that could potentially be used in the future to measure the areal extent of elevated $PM_{2.5}$ concentrations in the wintertime, when ambient $PM_{2.5}$ concentrations are normally at their worst. The pilot study included the following elements:

- A limited (three-vehicle) set of chassis dynamometer-based $PM_{2.5}$ emission tests of vehicles;
- The performance of on-road "vehicle following" measurements, including carbon monoxide (CO) and carbon dioxide (CO_2) measurements of the same three vehicles (above); and

- A brief instrument co-location measurement comparison.

The data from these early studies had limited value by themselves, but the studies provided important insights that guided planning and later data collection efforts.[3] The on-road CO/CO_2 measurements were unsuccessful because the available (tailpipe) instrument was not sufficiently sensitive for in-plume measurements (a purpose-selected CO_2 monitor of suitable range was successfully used later). Co-location sampling for the PM instrument was too spotty to be reliable, and the April sampling did not capture winter conditions (subsequent winter sampling was successful, due in part to the inclusion of systematic co-location monitoring). The dynamometer test facility was modified to measure PM, but the instrumentation was non-standard and measured only "gross emissions" (with no background correction), which was problematic to interpret (later testing under ADEC's sponsorship successfully used standard dilution tunnel-based EPA sampling methods with filtered dilution air[4]). But the first and foremost conclusion from the pilot study was that instrumented vehicle-based measurements of $PM_{2.5}$ were feasible and, with sufficient coverage over the winter months when both emissions and meteorology favor much higher ambient concentrations of $PM_{2.5}$, offered a practical method for assessing the areal extent of the $PM_{2.5}$ problem in and around Fairbanks.

A literature survey and report that was requested later that year by ADEC and prepared by Sierra Research (Sierra)[1] identified 13 critical gaps in knowledge and understanding about the magnitude, causes and solutions to the $PM_{2.5}$ problem. Although none of the gaps and questions were found to be amenable to definitive answers from information then available, the review identified and prioritized a series of activities designed to answer the most critical questions. To assess the areal extent of elevated $PM_{2.5}$, the review recommended a driving (sniffer) study, which it described as follows:

> *A comprehensive sampling survey in winter, with the most intensive sampling activity during predicted $PM_{2.5}$ episodes, offers the promise of defining the areal extent of elevated $PM_{2.5}$ concentrations. This has the potential not only to show the extent of, and areas that have and don't have, excessive public health risks from high $PM_{2.5}$ concentrations, but also to provide insight into the sources of the $PM_{2.5}$ emissions. The feasibility, practicality, and utility of this type of study in Fairbanks have already been demonstrated (at least for Spring weather conditions); however, to understand and map out the extent of the problem and identify critical hot spots, a study needs to be conducted under winter conditions that include low-temperature episodic $PM_{2.5}$ conditions.*

It was originally contemplated that an APS[*] would be used in mobile PM measurement, providing potentially valuable information about particle size in multiple ranges along with mass measurements, and CMAQ support was approved for that. However, a

[*] For example, TSI Model 3321 Aerodynamic Particle Sizer Spectrometer or equivalent (TSI Inc., Shoreview, MN).

suitable APS that met project needs for both on-the-fly mobile operation and affordability could not be identified. In its place, the Borough elected to base its sniffer particle size measurements on the use of a Thermo Fisher Scientific DataRAM4000.* This nephelometer is factory-calibrated to measure PM mass, but also uses multiple wavelength scattering measurements to infer and output in real time the median particle aerodynamic diameter. In addition, the instrument design was robust, well-proven for mobile use, and familiar to both ADEC and Borough staffs. For the RAMS, the Borough elected to use a familiar and relatively reliable, low-maintenance beta-attenuation monitor (BAM) † along with other well-proven aerometric instruments.

With CMAQ support, the aforementioned mobile monitoring commenced in the winter of 2007-2008. Further details on this monitoring are provided below.

2.2 Mobile $PM_{2.5}$ Sampling in 2007-2008

2.2.1 Purpose and Methods

During the winter of 2007-2008, the Borough and ADEC undertook supplemental $PM_{2.5}$ and related monitoring efforts with the goals of identifying hotspots, collecting upwind and downwind measurements to document source contributions, and assessing the spatial extent of elevated $PM_{2.5}$ concentrations that had been observed at a single downtown monitoring site in previous winters. The additional monitoring consisted primarily of the three elements listed below.

- A RAMS trailer equipped with a BAM and other instruments. This was deployed for periods of two to four weeks each at various Borough sites throughout the winter.

- A sampling sniffer van equipped with a BGI $PM_{2.5}$ cyclone,‡ a (borrowed) DataRAM 4000 with inline heater (an all-metal, vehicle-grounded sampling line was used with short silicon rubber couplings and the vehicle was grounded using a static discharge rod), a Garmin E-trex Summit GPS, and a dual-channel Omega temperature logger. The van was operated by a two-person team who typically drove two multi-hour routes, mostly between 9 am and 6 pm, on each sampling day. The generally defined routes may be characterized simply as "neighborhood" (downtown Fairbanks and nearby), "hills" around Fairbanks, North Pole, and general driving. Borough staff members also made repeated brief

* DataRAM4000, Thermo Fisher Scientific, Franklin, MA.

† A BAM, or beta attenuation monitor, is a type of PM measurement instrument that relies on measuring the removal (attenuation) of electrons by PM mass in order to infer the PM mass concentration between a radioactive beta source and detector; it's essentially a quantitative measurement version of a home smoke detector with a sophisticated, high-precision control and calibrated measurement system.

‡ The cyclone was used in place of the impactors provided with the DataRAM4000 in order to minimize the time and labor required for removal of the trapped large particle fraction, to avoid the requirement for regular oiling of the impactor plate, and to provide a greater reservoir for collected coarse particles (if, for example, sampling was conducted during conditions of ice fog, which could quickly overload an impactor plate).

stops at specified locations (for instrument calibration) and took time- and date-stamped photographs of ice fog, plumes, selected emission sources, etc. (These photographs can also be effectively position-stamped by comparison with GPS records.) Events and other information about the drives were documented in written logs.

- A BAM and FRM measurement site at the Borough's Transportation Department on Peger Road. This site was also the start and/or end point for most drives and could therefore be used to compare instrument response. To that end, most drives began[*] and/or ended with a brief period of co-located sampling at the Peger Road site.

The Borough's RAMS trailer and Peger Road measurements included the winter period from November 1, 2007, through March 31, 2008. However, the sniffer monitoring didn't begin until late January 2008 and, as discussed below, experienced startup problems that limited the capture and usefulness of the data prior to February 2008. The monitoring continued through April 2, 2008, although subsequent analysis was restricted to the February-March portion of the sampling window.

2.2.2 Findings

Mobile monitoring data and certain other special purpose PM monitoring data collected by the Borough were, in the early years of sampling, analyzed by Sierra. As documented in a technical memorandum prepared for ADEC by Sierra,[5] preliminary measurements from the downtown monitor and RAMS trailer showed that elevated $PM_{2.5}$ concentrations occurred in downtown Fairbanks, in parts of North Pole, and at isolated hot spots in the region. Daily average $PM_{2.5}$ concentrations measured at the downtown BAM[†] equaled or exceeded 35.5 µg/m^3 on 24 separate days between November 1, 2007, through March 31, 2008. Exceedances were also recorded by daily BAM measurements at Peger Road and in North Pole (which had very limited monitoring) on several of these days. Mobile monitoring measurements corroborated these patterns and provided substantially greater spatial description. For example, monitoring showed higher $PM_{2.5}$ concentrations in downtown Fairbanks, in North Pole, and at identified hot spots throughout the region.

[*] Prior to driving, Borough staff routinely checked DataRAM sample flow using a DryCal DC-2 flow calibrator. After some experimentation by Borough staff and at the suggestion of Sierra Research, the set point for the active flow control of the DataRAM, which was inside the heated passenger compartment of the van, was increased (from the nominal 2 liters minute to about 2.5 liters per minute, determined experimentally) to provide a flow rate at the cyclone (which was outside the vehicle and drawing sample air at ambient temperature) that gave a cutpoint of about 2.5 microns (based on the cyclone's published response curve and average outside temperatures).

[†] At the downtown site, BAM measurements were highly correlated with same site's FRM measurements (r^2 = 0.98), but the BAM read higher by 32%. Calibrating BAM values to match the FRM reduced the number of BAM-based exceedance days from 24 to 14. By comparison, the number of exceedance days based on the Peger Road BAM results was 17 (no calibration was applied because none was necessary at Peger for agreement with the co-located FRM there).

The highest 24-hour average and hourly $PM_{2.5}$ concentrations (BAM and RAMS measurements) tended to coincide with the lowest temperatures and on the Valley floor (elevation about 135 meters above sea level at the downtown monitoring site). During episodes of low temperature, mobile $PM_{2.5}$ measurements were significantly and sharply higher at elevations below about 150 meters, coinciding with the height of the mixed layer as measured using the temperature probe on the vehicle. Except for isolated $PM_{2.5}$ hot spots, average concentrations at the highest elevations (above 400 m) were about an order of magnitude lower than those on the Valley floor.

The high concentrations regionally at low temperatures were almost certainly dominated by two factors: (1) reduced atmospheric ventilation (i.e., low or undetectable wind speeds and very low mixing depth), and (2) increased space heating demand. Ice fog, which can occur at temperatures below about -20º F, sometimes occurred along with high $PM_{2.5}$ concentrations, but exceedances also occurred when ice fog was absent and lower-level $PM_{2.5}$ concentrations occurred when ice fog was present.

The mobile instrumented vehicle surveys conducted by Borough staff showed that isolated $PM_{2.5}$ hot spots occurred throughout the region under a variety of meteorological conditions and tended to be associated with wood burning (the written log frequently indicated smell or sight of wood smoke coincident with high concentrations) either from OWBs or wood stoves. Concentrations in excess of 1,000 µg/m^3 were measured[*] in the vicinity of a number of OWBs. Such concentrations have a high potential to create a public nuisance and may be a threat to public health if, as expected, OWB usage for space heating continues to increase.

Photos taken by Borough staff consistently appeared to show the plumes from major emission sources (Aurora Energy, UAF and Fort Wainwright Power Plants, and Fairbanks Memorial Hospital) penetrating the surface-based ice fog layer and thereby being substantially decoupled from ground-based measurements and human exposure during periods of highest concentration.

BAM measurements at Peger Road closely tracked 24-hour average Federal Reference Method $PM_{2.5}$ measurements (r^2 = 0.94, slope forced thru the origin = 1.00), and measurements from the vehicle-mounted DataRAM4000 equipped with $PM_{2.5}$ cyclone used by Borough staff in the mobile monitoring program were correlated with hourly BAM measurements at Peger Road (r^2 = 0.97, slope forced thru origin = 0.96). However, measurements from the BAM at the downtown monitoring site were, on average, 32% higher (r^2 = 0.98) than co-located FRM measurements (speciation monitor total mass measurements at the same site agreed with the FRM).

[*] Such instantaneous measurements should not be compared directly with the level of the national ambient air quality standard, which is a 24-hour average standard, but should more properly be viewed as a warning indicator that hot spot sites in the vicinity could experience exceedance-level concentrations if there were a persistence of meteorological conditions and emissions.

2.3 RAMS Trailer

In 2005, the Borough proposed to the U.S. EPA and began implementing a Plan[6] for designing, assembling and operating a RAMS to measure CO concentrations at a number of sites within and around the downtown Fairbanks area. The Plan entailed purchase and customization of a 7'x14' insulated, temperature-conditioned trailer to house air quality and meteorological monitoring instruments, which was completed in 2007. A critical aspect of the RAMS-based approach to monitoring was to use approved FRMs for all key measurements, including CO, $PM_{2.5}$, and meteorological variables.[*] In addition, all concentration measurements were reviewed in accordance with a strict quality assurance plan on time scales that were compatible with computing 1-hour, 8-hour, and (for $PM_{2.5}$) 24-hour average from the measured concentrations.

As completed and deployed in the winter of 2007-2008, the RAMS trailer's instrumentation included the following equipment:

- TECO 48C CO Monitor (the same model of ambient air monitor that is current used by the Borough);
- MetOne 50.5 Sonic Wind Measurement System;
- MetOne 064 Temperature Sensor;
- MetOne Beta Attenuation ($PM_{2.5}$) Monitor;
- MetOne 083D Relative Humidity Sensor;
- MetOne 091 Barometric Pressure Sensor;
- ESC Data Logger;
- Zero, span and precision compressed gases;
- Thermostatic temperature control; and
- Battery backup uninterruptible power supplies and other essential utilities.

During the winter of 2007-2008, the RAMS trailer was deployed and operated (intermittently) at 11 sites[†] in and around Fairbanks, primarily for CO spatial mapping.[7] As discussed in the next section, the trailer was subsequently deployed at multiple sites in and around Fairbanks to aid in the spatial mapping of $PM_{2.5}$ and its constituents.

###

[*] FRMs for $PM_{2.5}$ are not amenable to use in moving vehicles (e.g. the sniffer vehicle), which is the reason why other, more mechanically robust methods were used in the sniffer.

[†] Because the CO monitor used in the RAMS trailer is identical to those used in the Borough's permanent air monitoring sites, the original plan for brief periods of sampling while co-located with permanent sites was no longer needed for CO. Co-located monitoring was, however, still conducted with the Borough's $PM_{2.5}$ monitoring site at Peger Road.

3. CMAQ-SUPPORTED MOBILE MONITORING IN 2008, 2009, AND 2010

This section summarizes the main purposes, activities, and results from the Borough's CMAQ-sponsored Neighborhood Characterization Study in the winters of 2008-2009, 2009-2010, and 2010-2011.

3.1 Sniffer and RAMS Mobile Sampling in 2008-2009

The main purposes of the instrumented vehicle (sniffer) monitoring study in 2008-2009 were to measure $PM_{2.5}$ concentrations in and around Fairbanks using an instrumented vehicle in order to:

1. Better characterize the spatial extent and relative severity of the winter time $PM_{2.5}$ problem;

2. Better characterize changes in temporal profiles of concentration; and

3. Gain insight into the sources (e.g., wood burning, other stationary sources, Diesels and other vehicles) and their relative importance.

In order to accurately calibrate the on-board $PM_{2.5}$ instruments, a necessary part of the study included the collection and analysis of an aerometric database that contained (preliminary) FRM air quality data collected by the Borough and ADEC. In addition, the database included meteorological data ("Local Climatological Data") provided by the Alaska State Climatologist and other data. The preliminary air quality data were obtained through the use of both FRMs and non-standard (mostly instrumental) methods that provided finer time resolution. Merging these data and performing quality control (Q/C) screening were major aspects of this work.

The instrumented vehicle was a 2007 Ford Explorer owned by the Borough and equipped, as per specification and design by Sierra, with the following equipment:

- Thermo Fisher Scientific DataRAM4000 PM monitor (Thermo Fisher Scientific, Franklin, MA), which was custom- mounted in the front passenger area in place of the (removed) passenger seat;

- BGI model SCC1.062 $PM_{2.5}$ sampling cyclone (BGI, Inc., Waltham, MA);

- Sample line heaters (two Thermo Fisher Scientific DR-TCH temperature conditioning heaters in series);
- Garmin E-trex Summit GPS (Garmin International, Inc., Olathe, KS);
- Drycal flow calibrator (Bios International, Butler, NJ);
- Two Omega OM-CP temperature loggers (Omega Engineering, Inc., Stamford, CT);
- DieHard (Sears) 750W power inverter; and
- Custom stainless steel ¼” dia. sampling lines coupled by conductive tubing.

The field study portion of the sniffer measurement program was conducted by driving the instrumented vehicle on public streets in order to sample $PM_{2.5}$ in and around Fairbanks and as far away as the City of North Pole. Equipment was procured, configured, and installed in the sampling vehicle in the fall of 2008, and all of the driving reported herein occurred between 11/14/08 and 4/17/09. Driving procedures were also developed in the fall[8] and evolved through the early weeks of driving.

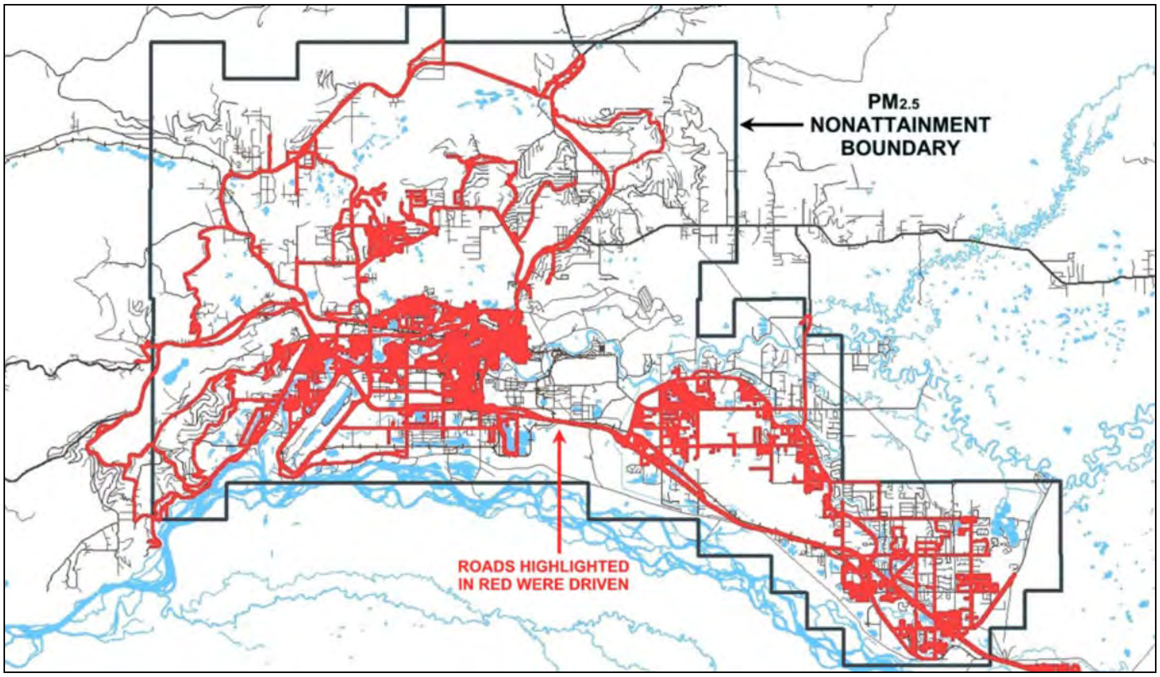
Individual drives averaged two to three hours each and followed generally prescribed routes that were termed “City,” “Hills,” “North Pole,” or “other,” reflecting the areas and issues of primary concern. The “other” designation was primarily used to describe special-purpose drives to investigate smoke complaints, identify or attempt to track plumes from individual point sources, etc. Essentially all of the driving after February was of the latter type. Despite having prescribed drives, drive teams were encouraged to “follow plumes and high neighborhood concentrations,” driving slightly different local roads each time in an effort to help locate any and all major neighborhood PM emission sources.

The two-person drive teams typically attempted two to four drives per day during the winter, with more drives during $PM_{2.5}$ episodes and fewer or none when air quality was good. Half of the prescribed drives were intended to be “City” drives. Driving was conducted both day and night and during weekdays and weekends. All drives started and/or ended at the Borough Transportation Department (Peger Road). Collocation $PM_{2.5}$ monitoring was originally performed immediately adjacent to the Peger Road (BAM) but this was later shifted to Nordale School (TEOM/FDMS[*]). Figure 3-1 shows the road coverage of sniffer driving throughout the nonattainment area. Additional information has been provided elsewhere.[9]

---

[*] TEOM/FDMS means Tapered Element Oscillating Microbalance/Filter Dynamic Measurement System. It is a more sophisticated PM measuring system that is capable of short-term (<1 hr) measurements that can also be averaged mathematically to approximate integrated filter measurements over the corresponding interval.

Figure 3-1
Roads Driven in Winter 2008-2009 to Collect $PM_{2.5}$ Measurements within the Fairbanks Nonattainment Area



Beginning in December, drivers recorded* audio notes, which they later transcribed to text. The teams photographed plumes, any unusual meteorological conditions or events, and noteworthy emission sources, all of which became part of the permanent driving record.

In all, there were about 140 sniffer drives conducted on a total of 95 days in the winter of 2008-2009, resulting in 370 hours of recorded data and providing about 660,000 valid data records (one GPS and DataRAM measurement about every two seconds). Seventeen of the driving days were also estimated exceedance days for $PM_{2.5}$†, defined here as days when the downtown BAM recorded a 24-hour average $PM_{2.5}$ concentration greater than 35 µg/m^3 (there were about 25 such days in total in the 2008-2009 winter season). Of the 17 exceedance days for which there are drive data, 3 were days having daily BAM concentrations of about 50 µg/m^3. As a point of comparison, the application of U.S. EPA guidance[10,11] for calculating the "design day" $PM_{2.5}$ concentration in Fairbanks leads to a final value of 44.7 µg/m^3.

* Audio notes were recorded using a Livescribe Digital pen (2 gigabyte), Livescribe, Oakland, CA.
† Formally, an "exceedance day" can only occur when air quality is measured using an FRM monitor, which the downtown BAM is not. However, FRM monitoring is performed only every third day, whereas the automated BAM operates every day (except for maintenance issues).

3.2 Sniffer, Vehicle-following, and RAMS Sampling in 2009-2010

Sniffer vehicle neighborhood sampling continued in 2009-2010 in much the same fashion and level of staff effort as in the prior winter, but with two important changes: replacement of the sniffer vehicle by a newer model, and instrumentation of the new vehicle to perform "plume following." This study element relied upon critical CMAQ sponsored support from Borough staff to install and operate additional equipment* in the Borough's sniffer vehicle, including the following:

- Sensitive CO_2 monitor;
- Solenoid-switched dual sampling cyclones (bumper and 11-ft level, see Figure 3-2);
- Laptop computer based real-time display and data logging; and
- CO_2 and flow-calibration equipment.

The added equipment permitted the sniffer to measure not only PM, but also CO_2 in the plumes of light- and heavy-duty vehicles on-road (including those with tall stacks). In addition, a team of two Borough staffers operated the modified sniffer for two weeks collecting on-road plume data and, later, transcribing and editing their audio notes. Details about the plume following study are presented elsewhere.[4]

Figure 3-2
Air Sampling "Sniffer" Vehicle Showing Dual Sampling Cyclones

* Equipment was selected, configured, and tested by Sierra under ADEC sponsorship.

In addition to the aforementioned sniffer work, the Borough relied upon CMAQ support in 2009-2010 to help conduct RAMS Trailer sampling at the Watershed Charter School (11/13/09 – 2/1/10) and at the Borough's Peger Rd. Maintenance Building parking lot (2/17/10 – 3/31/10). Results from that sampling, which continued to assist in documenting the spatial extent and seriousness of the Fairbanks $PM_{2.5}$ problem, are presented elsewhere.[2]

3.3 Sniffer and RAMS Mobile Sampling 2010-2011

Through CMAQ support, both sniffer and RAMS sampling continued in 2010-2011 in much the same fashion and level of effort as the two prior study periods (but without the two-week period of sniffer plume sampling and CO_2 monitoring that was conducted in 2009-2010). In addition, the Borough staff established a database and spatial analysis procedures that permit individual drive results to be processed into isopleth maps. That conversion process, which used to require hours per map, can now be done in minutes.[12]

3.4 Results

Detailed discussion of the equipment, procedures, analysis, and results has been provided elsewhere.[13] A brief summary of the findings from the sniffer sampling is provided below.

1. The highest mobile monitoring concentrations of $PM_{2.5}$ were observed in the most densely populated areas (e.g., the cities of Fairbanks and North Pole).

2. Areas with low population density were generally found to have substantially lower concentrations (e.g., Goldstream Valley).

3. Concentrations, especially for daytime, along Airport Way (a busy arterial) were relatively high, but the source contribution was unclear, which underscores the need to better understand the motor vehicle contribution.

4. The highest mobile monitoring concentrations occurred from 4:00–6:00 pm, which was consistent with the downtown stationary monitor on high $PM_{2.5}$ days.

5. There were pockets of high concentrations that appeared to be located in neighborhoods that were older, had high levels of wood-burning, or were in areas of low elevation (see discussion below regarding "Hotspot Neighborhoods").

6. Throughout the region, localized impacts from individual OWBs/OCBs could sometimes be identified in elevated $PM_{2.5}$ values, both for individual drives and in concentrations averaged over numerous drives.

7. No clear evidence was found for ground-level $PM_{2.5}$ impacts from large, elevated stationary sources (e.g., power plants).

8. No ($PM_{2.5}$) data were collected at Ft. Wainwright. Given the proximity and potential importance, monitoring should be conducted there.

9. Spatial monitoring helped to identify the spatial extent of the problem and identify likely sources, while ruling out other sources, and it helped to prioritize areas where data need to be collected to better characterize the activities that generate emissions.

3.4.1 Hotspot Neighborhoods

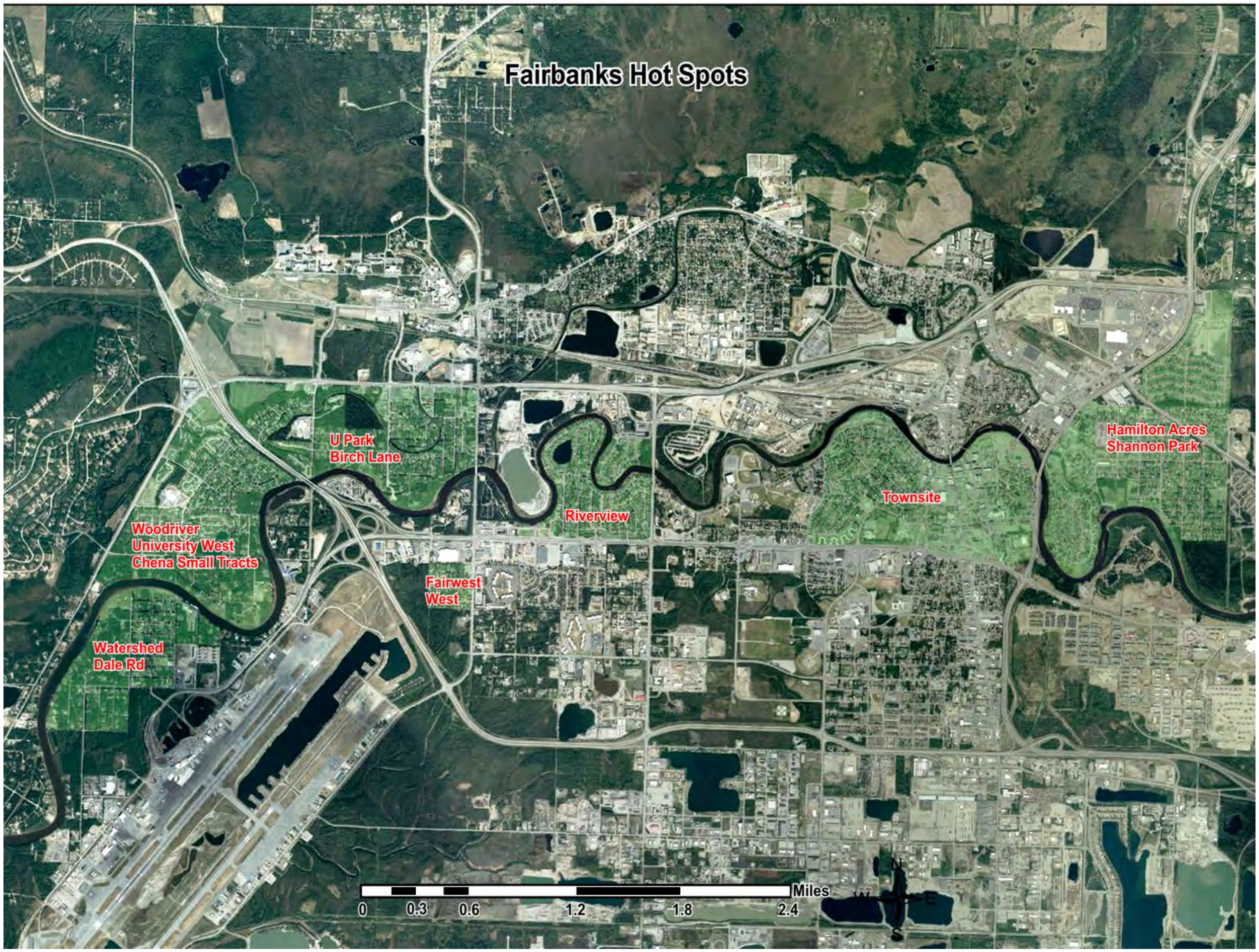
Descriptions and summaries of findings from the sniffer and RAMS sampling[14] and from chemical speciation trends, including RAMS data,[15] are being used in the development of the Fairbanks $PM_{2.5}$ SIP (in progress). But perhaps the most compelling single fact learned from this mobile monitoring was that $PM_{2.5}$ concentrations of concern were found to exist at times over most of the densely populated portions of the nonattainment area, including schools, medical facilities, and other sensitive receptors, as well as homes. This dispels the false notion, expressed by some, that high concentrations might exist only at or near the downtown monitor. To illustrate this, several graphical results from the Borough's mobile monitoring are discussed and provided below.

Figure 3-3 identifies the most severe and consistent hot-spot neighborhoods that have been identified over the three-winter sampling period when low temperatures and other meteorological conditions are conducive to episodes of high $PM_{2.5}$ concentrations. The seven hot spot neighborhoods identified in and immediately surrounding Fairbanks proper are listed below.

- Fairwest/West
- Hamilton Acres/Shannon Park
- Riverview
- Townsite
- University Park/Birch Lane
- Watershed/Dale Road
- Woodriver/University West/Chena Small Tracts

Children, the elderly, and the infirm are generally considered by the public health community to be among the sensitive groups[16] for adverse health effects due to exposure to $PM_{2.5}$, and several of these hot spots encompass schools and other sensitive receptors.

Figure 3-3
Most Severe and Consistent Neighborhood $PM_{2.5}$ Hot Spots in the Winters of 2008-2009, 2009-2010, 2010-2011



Source: Adapted from a figure provided by Borough staff, June 2012.

Figures 3-4 through 3-8 show isopleth maps, i.e., contour plots having lines of constant $PM_{2.5}$ mass concentrations. These annotated maps were prepared and data were compiled by Borough staff. The following description and disclaimer applies to each isopleth map:

> *This $PM_{2.5}$ concentration map is made from data collected by the Borough's instrumented "sniffer vehicle" traveling on public roads. This map is an instantaneous snapshot of what was happening at a particular location at one point in time (not a 24-hour average, and not a 1 hour average). The contouring is projected using a "natural neighbor" program, and is only a representation of different concentrations compared from one area to another. All data and results are preliminary. The contours (colors) correspond to the EPA $PM_{2.5}$ 24-hour levels from the Air Quality Index chart. If the 2-sec measured concentrations remained for 24 hours, this would be the health risk category.*

Figure 3-4 shows the focus of an extreme neighborhood $PM_{2.5}$ episode in North Pole on January 20, 2011, which appeared at the time of sampling to encompass North Pole Middle School and other sensitive receptors. In several cases, the computer-derived hot spots appeared to be associated with identified outdoor hydronic heaters. The data in the figure suggest that, except for hot spots in the vicinity of individually identified sources, the less densely populated area between the cities of Fairbanks and North Pole tends to have lower concentrations than observed in the more densely populated areas of the cities proper.

Figures 3-5 and 3-6 show samples of the spatial patterns of PM_{25} concentrations in the vicinity of Woodriver Elementary School during air quality episodes that occurred on February 1 and March 11, 2011. In each figure, the dotted line shows the route followed by the sniffer vehicle to better define the neighborhood hot spot. Woodriver School has been a focal point of public concerns about impacts from nearby OWB emissions, as well as concerns about private property rights.[17,18] Bringing objective ambient measurement data to bear in this dialogue has been a valuable benefit of the mobile monitoring program.

Figure 3-7 shows the measurement results from another "schools drive." This drive on March 2, 2011, which was one of the regular sniffer drives designed to survey schools, found peak concentrations near Ladd Elementary School and the downtown State Office Building (not labeled on this map). Figure 3-8 shows, for comparison, the spatial $PM_{2.5}$ concentrations from a schools drive on a relatively clean air day in 2012, where essentially all measured concentrations, albeit on a short-term basis, were below the concentration level of the NAAQS.

Figure 3-4
Example of an Extreme $PM_{2.5}$ Neighborhood Episode in North Pole, 1/20/11
(Preliminary – see text for isopleth map disclaimer)

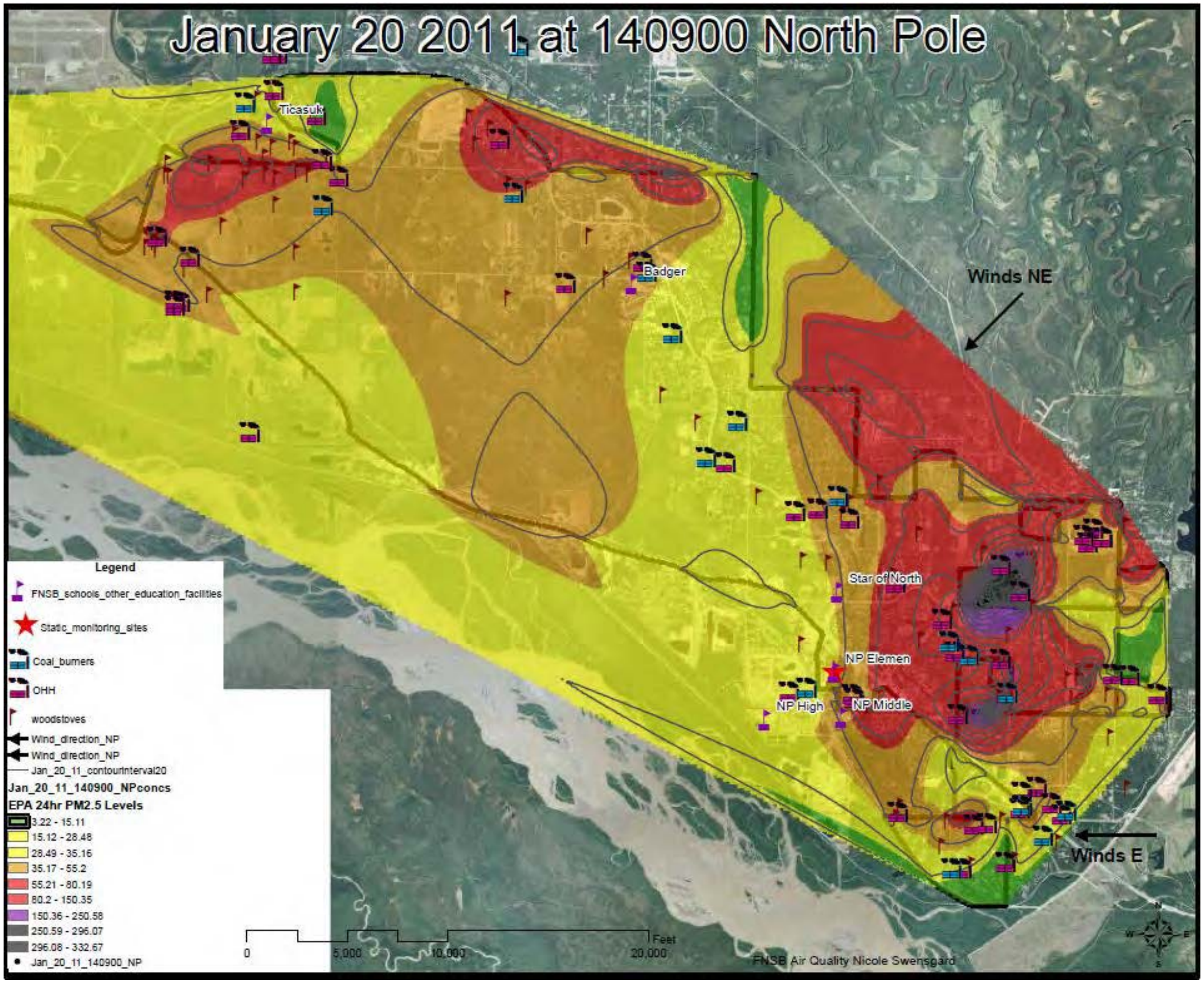


Figure 3-5
Example of Neighborhood $PM_{2.5}$ Mapping, Vicinity of Woodriver and Watershed Schools, 2/1/11
(Preliminary – see text for isopleth map disclaimer)

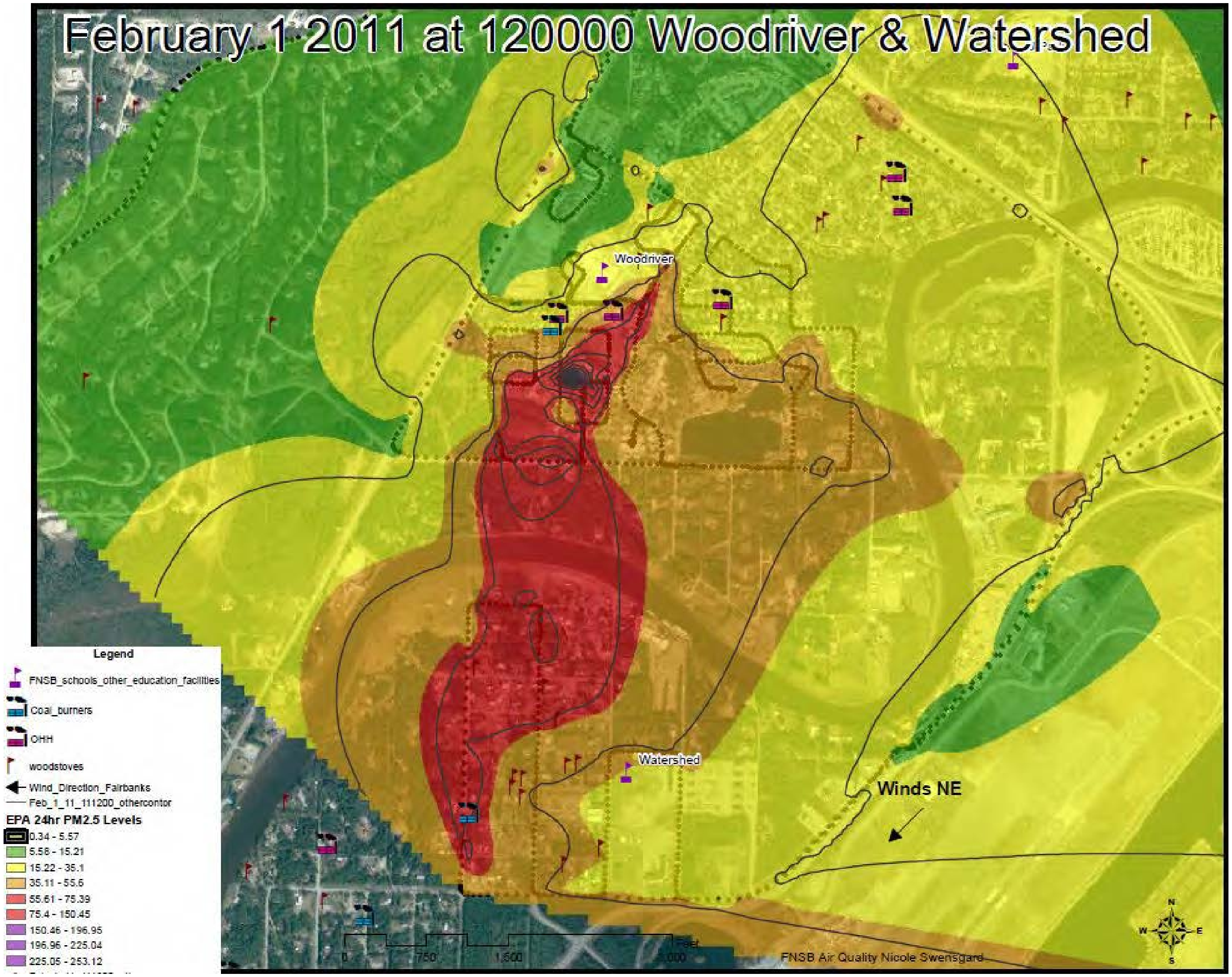


Figure 3-6
Example of Neighborhood $PM_{2.5}$ Mapping, Vicinity of Woodriver School, 3/11/11
(Preliminary - see text for isopleth map disclaimer)

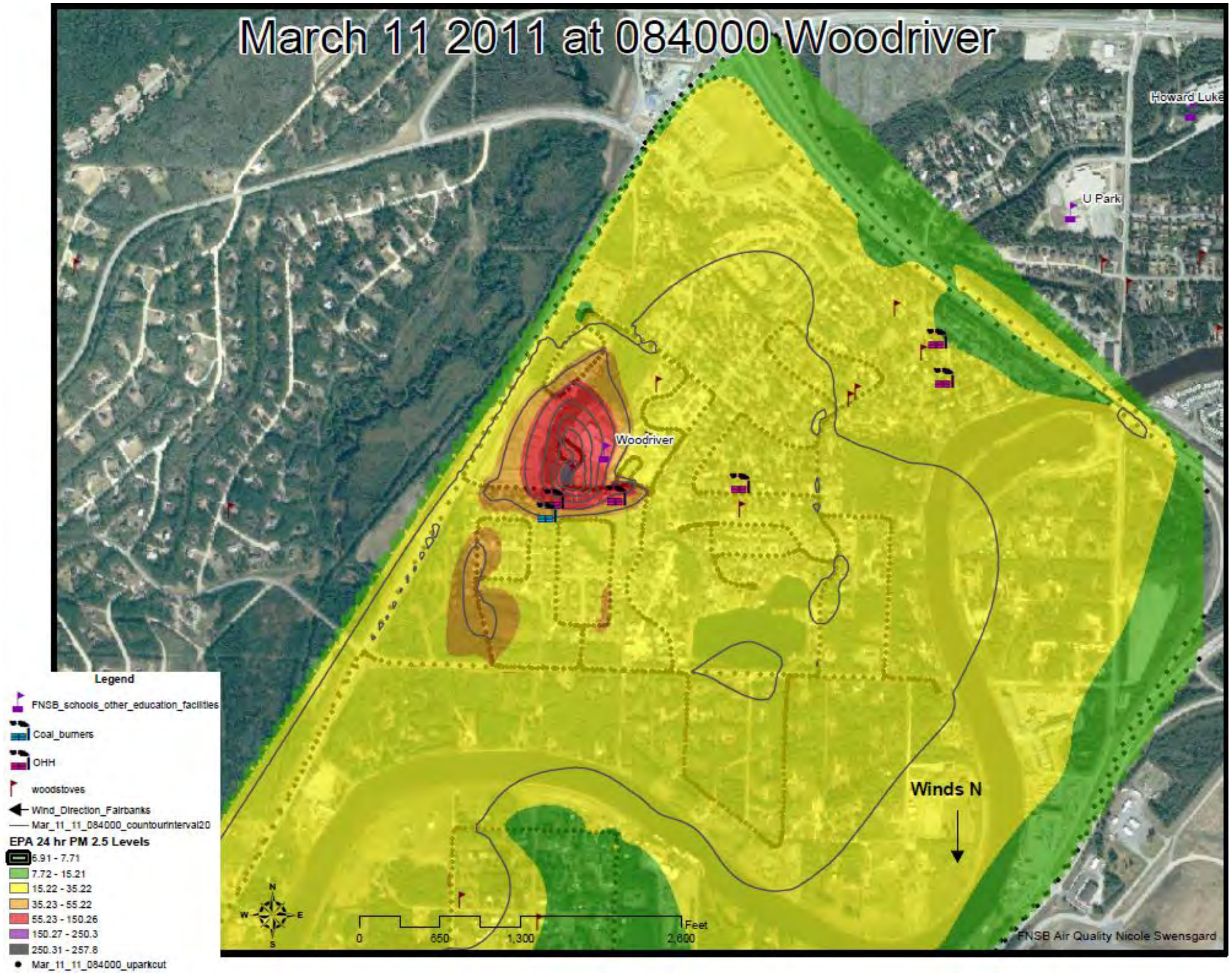


Figure 3-7
"Schools Drive" Showing Peak $PM_{2.5}$ Concentrations Near Several Schools, 3/2/11
(Preliminary – see text for isopleth map disclaimer)

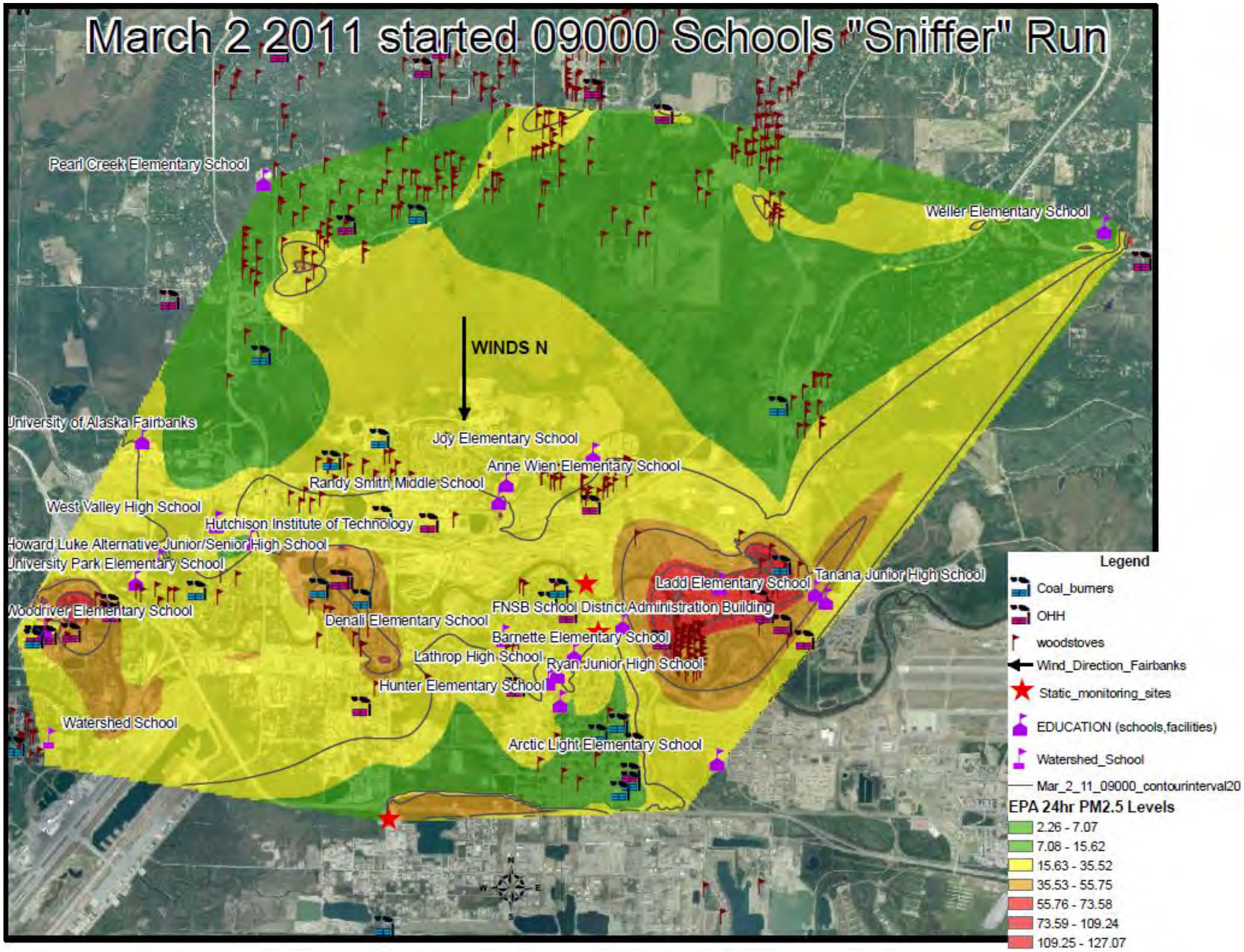
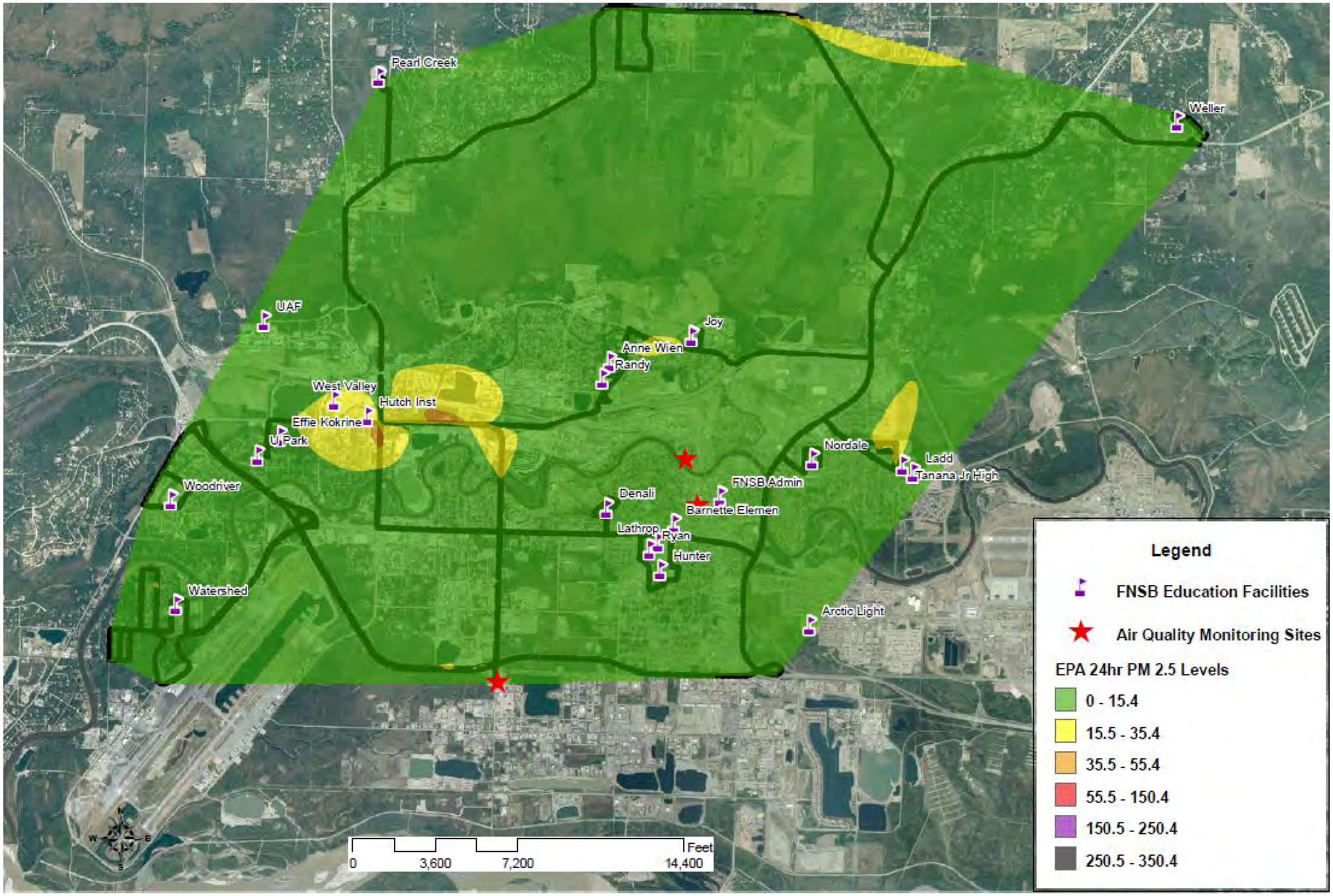
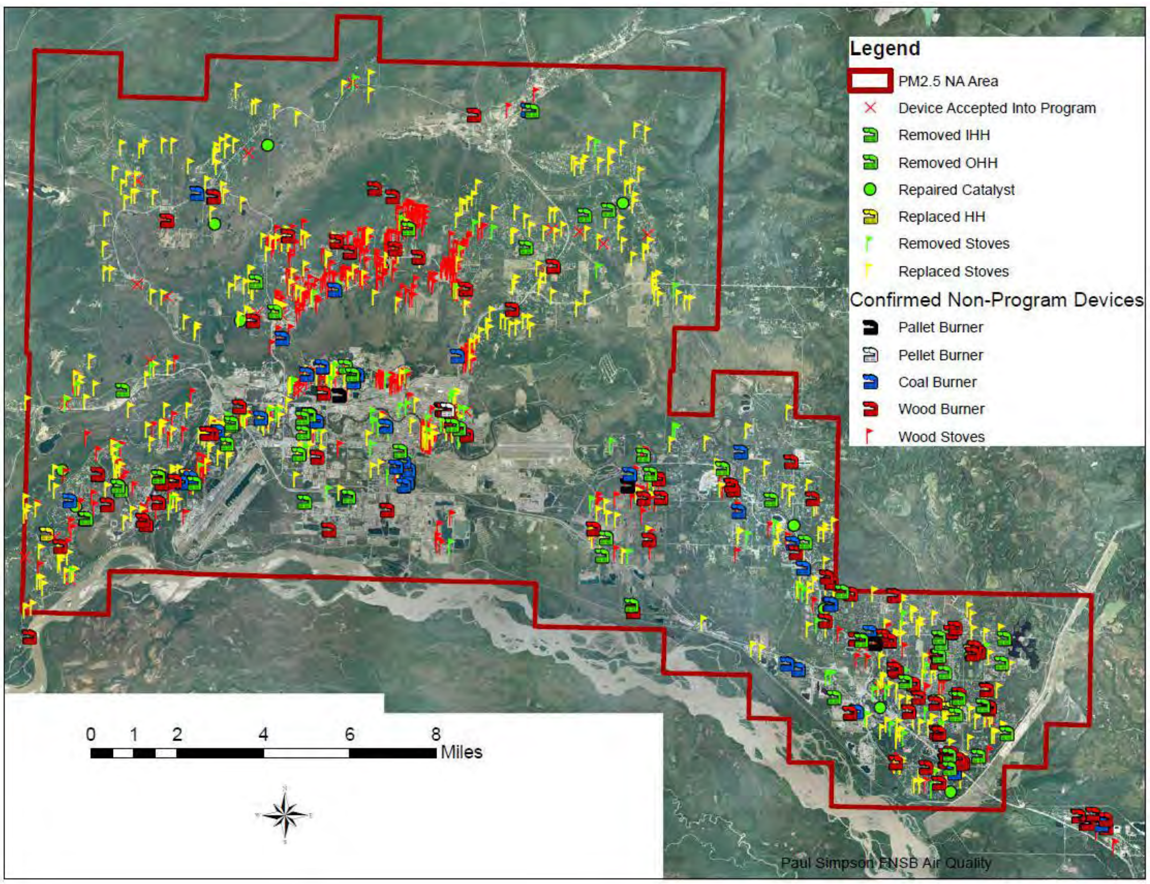


Figure 3-8
"Schools Drive" on a Day with Relatively Low $PM_{2.5}$ Concentrations, 3/2/12
(Preliminary – see text for isopleth map disclaimer)



Finally, a useful ancillary benefit of the mobile sampling has been to help locate and map PM emission sources. Figure 3-9 shows a current map of the Fairbanks nonattainment area, with known residential solid fuel combustion sources identified, including sources identified in the early years of sniffer vehicle operation and later augmented with information from the woodstove changeout program. Although the map depiction is known to be very incomplete, it does provide a spatial depiction of solid fuel burning households in the nonattainment area. A complete map in the nonattainment area would likely be almost solidly red, reflecting the fact that the majority of households are equipped to burn wood or coal.

Figure 3-9
Borough Map of Identified Residential Solid Fuel Combustion Emission Sources



3.5 CMAQ Support

CMAQ support for the Neighborhood Characterization and Mobile Monitoring Tasks and related tasks* was used to help fund the sniffer vehicle and RAMS instrumentation and the Borough staffing needed to install, service, and operate equipment in both.

The sniffer vehicle was outfitted by Borough I/M referee Kelly Shaw. All driving and data collection was done by Borough staff and coordinated by Todd Thompson, the Borough's driving coordinator. In addition, Borough staffer Thompson retrieved, archived, and periodically uploaded drive data from the DataRAMs, GPS unit, two temperature loggers, photographs, and drive notes, including Borough staff's transcriptions of their audio drive notes, to Sierra's FTP site for analysis by Sierra. A list of additional staff members supported by CMAQ to carry out the sniffer and RAMS setup and sampling is provided in Table 3-1.

Table 3-1
Staff Members Supported (in part) through Specified CMAQ Funding

Study Elements	Staff Members (permanent and temporary)
Sniffer Study (2008, 2009, 2010) and Plume Following (2009 only)	Jeremy Bahr Steve Gano Karen Remick Kelly Shaw Paul Simpson Nicole Swensgard Todd Thompson
RAMS Trailer (2008, 2009, 2010)	James McCormick (assembly and most servicing; occasional servicing by others listed above)

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* Related tasks included ADEC Monitoring Support, Data Analysis (increments 1 and 2), Borough Staffing, Procure Equipment and Deploy APS, Part-time Support, and Integration/Coordination.

4. SIGNIFICANCE OF THE SUBJECT STUDY

The Neighborhood Characterization Study has provided the Borough and ADEC with a much clearer and well-documented understanding of the spatial extent, severity, and sources of the wintertime $PM_{2.5}$ problem in Fairbanks.

The sniffer measurements of $PM_{2.5}$ showed highest concentrations in the most densely populated areas, in identifiable hot spot neighborhoods, and in localized areas in the vicinity of outdoor wood or coal boilers. By contrast, areas with lower population density, above the base of the inversion, and devoid of obvious sources tended to show much lower concentrations. These observations, together with the observation of highest concentrations associated with low temperatures and poor dispersion, add to the weight of evidence for a SIP strategy to selectively reduce residential space heating emissions.

Furthermore, these and other observations from the sniffer and the RAMS trailer show persuasively that $PM_{2.5}$ is not just a problem at a small number of stationary monitoring sites. Rather, it is a problem that exposes a relatively large number of Borough residents, including children and other sensitive populations, to potential adverse health effects from $PM_{2.5}$.

These demonstrations are critically important both for crafting and managing the air quality improvement strategies that the Borough and State must develop and implement to mitigate $PM_{2.5}$ exceedances, and as technical support and documentation for Alaska's $PM_{2.5}$ SIP.

Absent reliable spatial measurements from the sniffer and RAMS studies, ADEC and the Borough would have little more than data from a single monitoring site and uncalibrated and yet unfinished photochemical modeling study results on which to base the selection of emission control measures, and would be much more poorly informed.

###

5. REFERENCES

1. Memorandum to Alice Edwards, from Frank Di Genova and Robert Dulla, "Studies and Data Relevant to PM2.5 Emissions in and around Fairbanks," November 2, 2007.

2. Memorandum to Cindy Heil et al, from Craig Anderson and Robert Dulla, "Summary and Analysis of Fairbanks PM2.5 Data for Winter 2009-10," prepared for Alaska Department of Environmental Conservation by Sierra Research, August 25, 2010 (draft).

3. Di Genova, F. et al, "Tier 2 Gasoline Benefits in Alaska, Phase 2: Preliminary Investigation of Particulate Matter Emission Sources in Fairbanks, Alaska, with in-use Tier 2 Gasoline and Ultra Low Sulfur Diesel," prepared for Alaska Department of Environmental Conservation by Sierra Research, August 2007.

4. See, for example: "CMAQ Support for Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks, Alaska," prepared for the Alaska Department of Environmental Conservation by Sierra Research, September 11, 2012.

5. Memorandum to Alice Edwards, from Frank Di Genova and Robert Dulla, "Data Analysis for Winter 2007-08 Neighborhood Characterization ("Sniffer Lite") Study," August 20, 2008.

6. Conner, J., "Quality Assurance Project Plan for the Fairbanks North Star Borough Carbon Monoxide Spatial Mapping Study," Fairbanks North Star Borough, February 2005.

7. Di Genova, F., et al, "Fairbanks Carbon Monoxide Spatial Mapping Study," prepared for Fairbanks North Star Borough by Sierra Research and Rincon Ranch Associates, October 31, 2008.

8. Di Genova, F., "FNSB Sniffer Study Driver Protocol for Winter 2008-09" (draft), prepared by Sierra Research, December 17, 2008.

9. See, for example, "Fairbanks Air Quality Symposium Summary," available here: *http://co.fairbanks.ak.us/airquality/Docs/Symposium_Summary.pdf*

10. "Guideline on Data Handling Conventions for the PM NAAQS," EPA-454/R-99-008, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, April 1999.

11. See, for example, "Analytical Challenges," presented by Jim Conner at the Fairbanks Air Quality Symposium, July 15-17, 2009.

12. Personal communication with Borough staff, June 2012.

13. Memorandum to Alice Edwards from Frank Di Genova and Robert Dulla, "Technical Report on the Instrumented Vehicle Monitoring Study," Contract No. 18-3001-20-9B, July 27, 2009.

14. Di Genova, F. and Dulla, R., "Mobile $PM_{2.5}$ Measurements in Fairbanks in the Winter of 2008-09," presented at the Fairbanks Air Quality Symposium, July 15-17, 2008.

15. Dulla, R., "Chemical Speciation Trends of $PM_{2.5}$ in Fairbanks, AK," presented at the Fairbanks Air Quality Symposium, July 15-17, 2008.

16. Verbrugge, L., "Particulate Matter 2.5, Human Health Effects," Alaska Division of Public Health, presented at the Fairbanks Air Quality Symposium, July 15-17, 2008.

17. See, for example, "Outdoor Boilers' True Cost: Neighbors Bear the Burden," Letter to the Editor by Dr. Carl Benson, Fairbanks Daily News-Miner, September 25, 2011.

18. See, "Fairbanks Voters Offer Reasons for Voting Against or for Proposition 2," Fairbanks Daily News-Miner, October 5, 2011.

###

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CMAQ Support for Space Heating Study in Fairbanks, Alaska

prepared for:

Fairbanks North Star Borough

September 11, 2012

prepared by:

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CMAQ Support for Space Heating Study in Fairbanks, Alaska

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1. INTRODUCTION

In December 2008, Fairbanks was designated by the U.S. Environmental Protection Agency (EPA) as a $PM_{2.5}$[*] nonattainment area. That triggered the federal requirement for Alaska to prepare a State Implementation Plan (SIP) for Fairbanks to achieve and maintain the $PM_{2.5}$ national ambient air quality standard. To assist in preparing the SIP, and with the support of funding from the Congestion Mitigation and Air Quality Program (CMAQ), Fairbanks North Star Borough (FNSB) has sponsored a suite of emission measurement studies designed to better quantify winter $PM_{2.5}$ in Fairbanks. The results of this effort will provide the basis for quantifying the mobile source contribution to the overall emissions inventory. This report describes one of those studies—a CMAQ-supported study to measure and better characterize space heating emissions, which are believed to be the largest single contributor to the Fairbanks winter $PM_{2.5}$ problem.[†1]

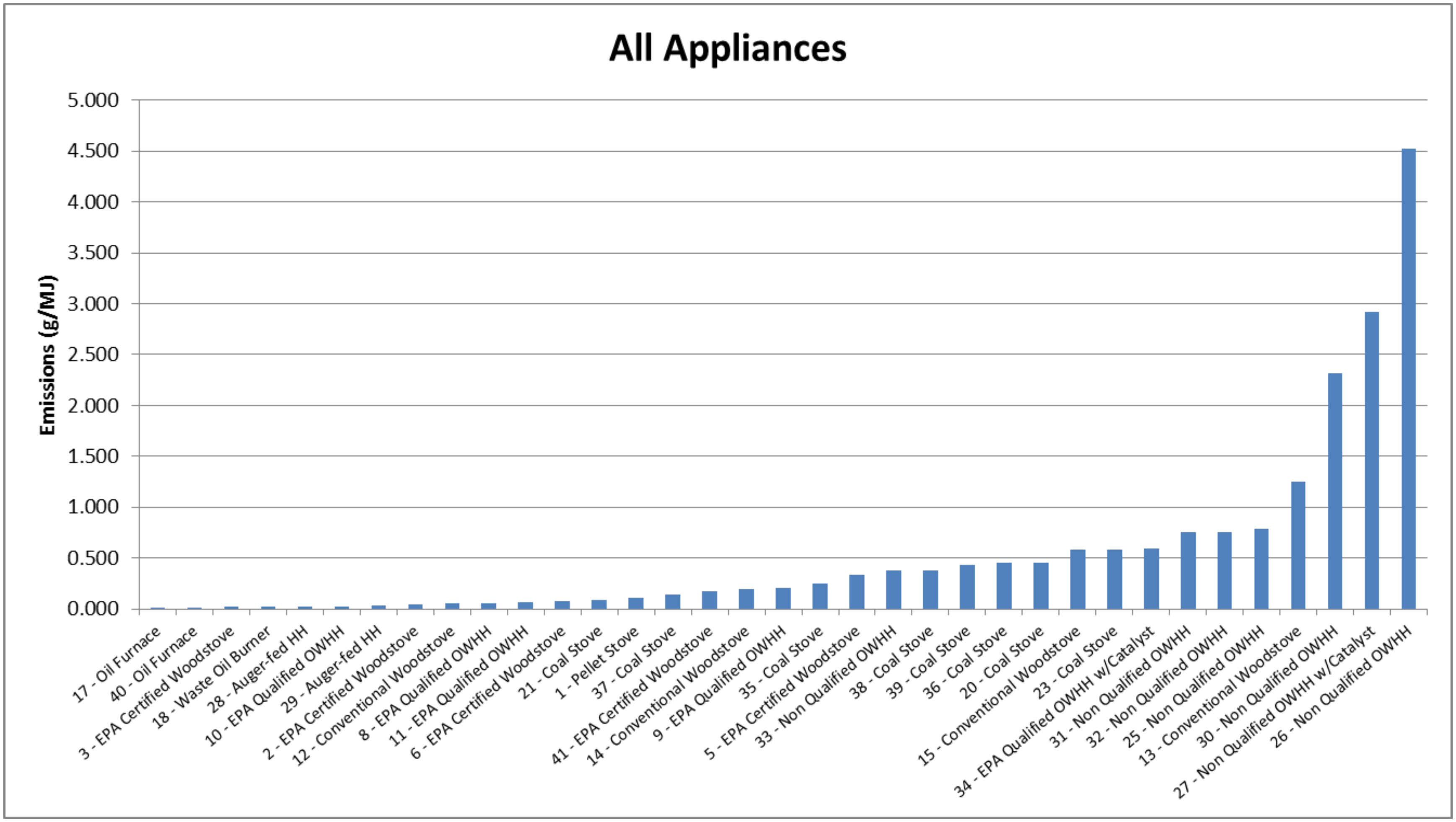
PM emission factors for residential space heating in Fairbanks, especially wood-burning, have not been well-quantified in the past, in part because emission factors for Alaska-specific fuels and typical Alaskan appliances have never before been systematically measured and analyzed. Accordingly, a key element of the Borough's emission inventory improvement efforts has been to better quantify and document the emission factors from typical residential space heating appliances when using local fuels.

With support from CMAQ, FNSB issued a Request for Proposals[2] (RFP) in October 2010 entitled "Measurement of Space Heating Emissions." The ultimate purpose of the procurement was to measure and provide detailed emission source profiles, suitable for Chemical Mass Balance (CMB) air quality modeling for six specified fuels local to Fairbanks (common wood fuels, heating oils, etc.) and to provide analysis of the composition of each type of fuel along with measurements of the emission factors for $PM_{2.5}$ and criteria pollutants. The Borough's procurement was awarded to OMNI-Test Laboratories, Inc. (OMNI), of Portland, Oregon, which conducted the testing in 2011. Results are summarized in Figure 1-1, from OMNI's report.[3]

> *(The figure) shows a comparison of all appliances tested. With the exception of some overlap, there is a clear delineation between cleaner burning appliances and high emissions appliances. The models that are EPA certified or qualified are, in general, more efficient and cleaner burning. Additionally, all of the continuously fed units – the auger-fed HH (hydronic heater), and the oil units – are designed for optimal burning conditions and efficiency, which is reflected in the data.*

[*] "$PM_{2.5}$" refers to fine particles having an aerodynamic diameter smaller than 2.5 microns.
[†] Numerical superscripts denote references provided in Section 4.

Figure 1-1
Particulate Emissions per Useful Heat Output, All Appliances



Source: OMNI-Test Laboratories, Inc.

OMNI's study is the first systematic and comprehensive attempt to quantify emission factors and emission profiles from space heating appliances and fuels in interior Alaska.

The caption from OMNI that is quoted above highlights one of the key findings from the study, namely that continuously fed space heaters (using any fuel type) tend to burn more cleanly than batch-fed units, (e.g., auger-fed compared to batch-fed coal, and pellets compared to cordwood). A second very significant finding was that PM emission factors from OMNI's selection of typical Alaskan appliances burning fuel samples from interior Alaska were significantly lower than the corresponding emission factors reported in EPA's AP-42 Emission Factor Handbook.[4] Absent the OMNI study, Alaska would have had little choice but to use AP-42 as the default source for these data. That, in turn, would have overestimated the $PM_{2.5}$ emissions from residential space heating, already the largest $PM_{2.5}$ contributor in the inventory, by several-fold, which would have seriously undermined the technical foundation for the Alaska $PM_{2.5}$ SIP.

Following this Introduction, Section 2 briefly reviews the methodology and highlights key results from the OMNI study, Section 3 explains the significance of the study, especially as related to the Alaska $PM_{2.5}$ SIP, and Section 4 provides a list of references.

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2. MEASUREMENT OF SPACE HEATING EMISSIONS BY OMNI

Under contract to FNSB, OMNI-Test Laboratories conducted a laboratory-based emission testing study consisting of 35 tests of nine space heating appliances, using six typical Fairbanks fuels. The main purposes of the study were to determine emission factors and emission source profiles for residential space heating in interior Alaska. The OMNI study was carried out in support of Alaska's $PM_{2.5}$ SIP and, consistent with EPA $PM_{2.5}$ SIP Guidance, OMNI measured both direct $PM_{2.5}$ emissions and gaseous emission precursors of $PM_{2.5}$ (sulfur dioxide [SO_2], oxides of nitrogen [NOx], and ammonia [NH_3]), along with $PM_{2.5}$ elemental profiles.

Using fuels from interior Alaska, OMNI conducted all emissions tests at its laboratory in Portland. 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 (RTI) using X-ray fluorescence (XRF), ion chromatography, and thermal/optical analysis.

2.1 Emission Factors from Wood-Burning Appliances

The main focus of OMNI's study was wood burning appliances and fuels because of their apparent significant contribution to $PM_{2.5}$ in the Fairbanks nonattainment area. Specific wood burning space heaters were selected for testing by OMNI because they represented either popular conventional models in interior Alaska or more advanced models, such as newer EPA-certified wood stoves and EPA-qualified Phase 2 Outdoor Wood Hydronic Heaters (OWHHs), that are expected to be representative of future trends. Additionally, one pellet heater was tested. In all, 20 of OMNI's 35 tests were conducted on wood-fired units.

OMNI's wood burning tests used fuel loadings and test protocols generally as prescribed by EPA Method 28 (where applicable)* and related EPA sampling methods. However, to provide the most realistic representation of Alaskan wood burning (and to meet the specifications of the Borough's RFP), split cordwood was used, rather than "crib wood" (i.e., dimensional lumber) as prescribed in the test method. In addition, OMNI used white spruce and paper birch (with bark), the two most common cordwood fuels in

* As summarized in OMNI's report, "EPA Method 28 pertains to the certification and auditing of wood heaters. This method prescribes the fueling protocol, conditions and procedures for determining the particulate emissions and burn rate of a burn event."

Fairbanks, rather than the Douglas Fir that was prescribed in the test method. Locally produced Alaska wood pellets were used for the pellet heater.

OMNI's testing was performed using representative Fairbanks fuel samples with as-received moisture levels. More specifically, the cordwood and other solid fuels tested by OMNI were collected in Fairbanks under typical fuel storage conditions and required to be preserved so as to maintain consistent moisture levels prior to their use in testing. In addition, all solid fuels were tested for moisture content by OMNI immediately prior to the test.

Fuel moisture content is usually reported on a "wet" or "as received" basis, i.e., the decimal fraction of the as-received fuel's weight that is water.[5] For example, a 100 lb. sample of wood fuel that contains 50 lbs. of water has 50% moisture content on a wet basis (0.50 = 50 lbs water/100 lbs total sample). However, expressed on a dry basis, the same sample has 100% moisture content (1.00 = 50 lbs. water/50 lbs. of oven-dry or bone-dry wood).

In contrast to the above description of fuels, emission factors for wood-fired appliances are commonly expressed as the mass of particle emissions per unit of *dry* fuel burned. This may seem counterintuitive at first, because for emissions and EF testing, wood fuel is typically burned in wet or as-received condition - it is rarely if ever burned in bone dry condition. But converting the amount of wet fuel burned to the corresponding amount of bone dry fuel when computing the EF allows one to normalize test results, thereby accounting for the relatively large direct emission factor differences due to fuel moisture. Accordingly, the convention that is used in much of the emissions research literature, in the EPA's AP-42,[6] and by OMNI in its report to FNSB, expresses EFs as mass of PM emissions per unit of wood burned on a "dry basis," e.g., grams of PM emitted per kg of wood burned (db, or dry basis). Emission factors expressed as lb/ton (db) differ from g/kg (db) by a factor of 0.5.

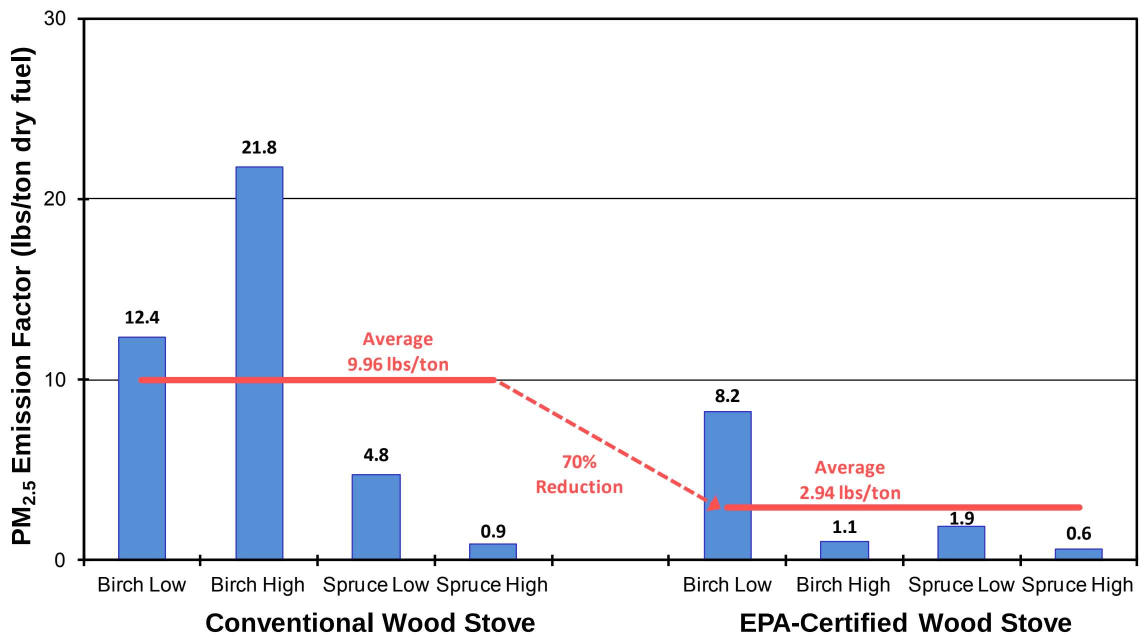
EPA test procedures were used as the basis for OMNI's emission testing, with adaptations as needed to improve the representativeness of testing or its practicality (for details, refer to the OMNI study report).**Error! Bookmark not defined.** EPA Method 28 was followed for solid fuel loadings and test duration. However, Method 28 specifies four different firing rates for each device, in effect requiring four different tests for each appliance/fuel combination, and then weighting the results to obtain both annual and heating season average emission values. Unfortunately, this ideal approach of conducting four tests for each appliance/fuel combination was not affordable for Fairbanks due to the size of Alaska's required appliance/fuel/firing rate test matrix.

The solution for Fairbanks was to conduct Method 28 testing for each appliance/fuel at either "low" firing rate or "low" and "max" firing rates only. The "low" firing rate was defined to be a nominal rate of 35% of maximum load. This load was selected by FNSB for two reasons. First, it is very close to and only slightly above the heating season average weighted load that is prescribed for a Method 28 test, which is 34%. Second, it is very close to, and only slightly below, the center of the range for the most frequent (i.e., most heavily weighted) mode of the Method 28 test, which is Category 3. This

Category has a firing rate of 25–50% of maximum, and it is weighted at 0.450 for the heating season average, i.e., it accounts for nearly half of the firing during the heating season. By also including a maximum firing rate where practical (corresponding to Category 4 of Method 28), the Borough attempted to capture both the average (g/kg) emission factor (primarily for emission inventory purposes) and the maximum or near maximum (g/hr) emission rate for other evaluation purposes.

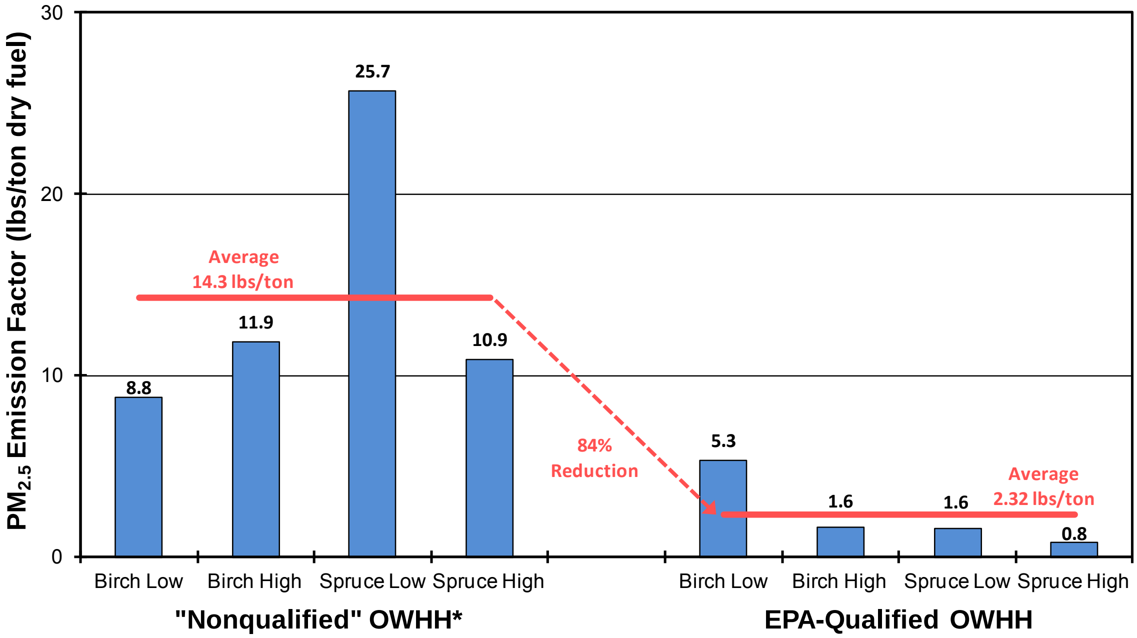
A sampling of OMNI's test results for wood stoves and OWHHs is presented in Figures 2-1 and 2-2.* The figures show emission factors for wood stoves and OWHHs, respectively, expressed as pounds of $PM_{2.5}$ emitted per ton of dry wood burned. Figure 2-1 contrasts the measured emission factors for EPA-certified and conventional wood stoves, and Figure 2-2 shows EPA-qualified and conventional OWHHs. Both figures show results for the low and high firing rates, as described earlier. The generally consistent patterns are interpreted as a positive reflection of the quality of the data, and the reduced emission factors for federally certified and qualified combustion units comport with expectations based on published studies. However, the Alaska fuel- and appliance-specific emission factors for wood burning tend to be lower than those reported in AP-42, EPA's Emission Factor Handbook,[4] as discussed later in this section.

Figure 2-1
$PM_{2.5}$ Emission Factors from OMNI Testing for Conventional (left) & EPA-Certified (right) Wood Stoves, using Birch or Spruce and Low or High Firing Rates



* Interpretation of OMNI's data shown in Figure 2-2 for the nonqualified OWHH requires caution because, according to OMNI, "This unit produced an extreme amount of particulate matter and heat in the flue." See OMNI's report for details.

Figure 2-2
$PM_{2.5}$ Emission Factors from OMNI Testing for "Non-Qualified"* (left) & EPA-Qualified (right) OWHHs using Birch or Spruce and Low or High Firing Rates



*See narrative for discussion of "dry fuel"; see OMNI's caution about non-qualified OWHH test results.

2.2 Emission Factors from Oil-fired Appliances

The vast majority of households in Fairbanks have central oil furnaces and, according to recent telephone survey data, about two-thirds of the residential heating in Fairbanks (BTU basis) is by central oil burning systems.[7] Therefore, despite the expected lower PM emission factors compared to wood, the Borough's procurement provided for testing of a central heater with Nos. 1 and 2 heating oils (used in Fairbanks in about a 1:3 ratio) and of a waste (motor) oil-fired space heater.

OMNI sampled the same suite of pollutants for oil burners as for wood, but the key pollutant of interest for oil burners was SO_2 due to both the much higher concentration of sulfur found in oil and the predominance of oil burning in Fairbanks. EPA's emission factor guidance document, AP-42, states that "On average, more than 95% of the fuel sulfur is converted to SO_2, about 1 to 5 percent is further oxidized to sulfur trioxide (SO_3), and 1 to 3 percent is emitted as sulfate particulate." Furthermore, SO_2 is, according to EPA's $PM_{2.5}$ SIP guidance, presumed to be a precursor of secondary $PM_{2.5}$. Thus, oil burning appliances may contribute to both primary and secondary $PM_{2.5}$ sulfate in the atmosphere.

Samples of Nos. 1 and 2 fuel oil and waste oil were collected by FNSB staff, analyzed for OMNI by SRI, and found to have sulfur contents of 896 ppm, 2,566 ppm, and 3,020 ppm by weight, respectively (see Table 2-1). Also shown in Table 2-1 are three alternative SO_2 emission factors, all of which are in units of grams of SO_2 emitted per kilogram of oil burned. Column 1 shows the range of emission factors based strictly on the SRI-measured sulfur contents and on the 95-100% sulfur to SO_2 conversion rate for oil combustion documented in AP-42. Column 2 shows, for each fuel, the corresponding emission factor based on 100% conversion of sulfur but after first subtracting the PM sulfur contributions on OMNI's PM filter samples (measured by Research Triangle Institute). These data are confirmatory regarding the SO_2 fraction in that they fall within the range anticipated based on AP-42. The third column shows an independent measure of the SO_2 emission factor by OMNI, although in this case, the emission factors for all three oils are below the levels anticipated based on fuel sulfur content, suggesting these measurements are suspect. The precise reason for the lower values in OMNI's SO_2 measurement-based factors is not known; however, it is recognized that the latter approach is a more complex estimate because it requires accurate calibration and measurement of not only SO_2 in the dilution tunnel, but also a tracer gas in both the hot stack and the dilution tunnel, along with accurate alignment of all measurement traces.

Two final points are worth noting with respect to oil combustion emission factors. First, the emission factors for SO_2 and SO_3 shown in AP-42's Table 1.3-1 imply a slightly higher proportion of fuel sulfur emitted as SO_2 for residential furnaces (98.9%) than for other fuel burning sources. This is consistent with and lends credence to the relatively high SO_2 fractions (i.e., small PM correction) observed from the OMNI/SRI/RTI measurements. Second, the oil burners were designed for and emission tested by OMNI at a single firing rate (there were no firing rate issues such as occurred with the wood burning appliances).

Table 2-1
Fuel Sulfur and SO_2 Emission Factors for Three Fairbanks Oil Samples

		Alternative SO_2 Emission Factors: (grams of SO_2 per kg of fuel burned)		
Fuel	**Ppm Sulfur (by weight) from SRI**	**Column 1 Range, assuming 95-100% of fuel S emitted as SO_2**	**Column 2 All fuel S Emitted as SO_2 except as measured on $PM_{2.5}$ filters by XRF**	**Column 3 Emission Factor from OMNI SO_2 (and other) measurements**
No. 1 Fuel Oil	896	1.70 - 1.79	1.77	1.25
No. 2 Fuel Oil	2,566	4.88 - 5.13	5.12	2.10
Waste (Motor) Oil	3,020	5.74 - 6.04	5.93	4.76

We conclude from all of the above that the most consistent and conservative emission factor for SO_2 is that derived from the direct fuel sulfur based method as reflected in AP-42. Accordingly, application of the fuel sulfur based method with 100% SO_2 conversion, and use of the SRI fuel sulfur measurements for oil collected under the current CMAQ-supported study, has been assumed in developing the Fairbanks SIP emissions inventory. By comparison, the emission factor measurement of SO_2 by OMNI requires more complicated calculations and untestable assumptions and, in our opinion, is less reliable than the above method based upon mass balance of sulfur. Furthermore, considering the closeness of the OMNI PM sulfur adjusted values (Column 2) to the 100% S conversion based emission factors (upper range limit of Column 1), the latter were used for the SIP-based inventory without adjustment for sulfur in the PM.

2.3 Emission Factors for Coal

In addition to wood and oil fuels, OMNI measured the emissions from several residential heaters burning Alaskan (Usibelli) subbituminous coal (wet, dry, lump, and stoker). Currently, coal is not widely used as a residential heating fuel in Fairbanks, and no EPA source test methods exist for residential coal stoves. The only AP-42 emission factor data available are from testing of much larger coal-fired boilers.

Under subcontract to OMNI, Twin Ports Testing (TPT) analyzed Alaskan coal samples that had been collected by Borough staff, stored in sealed drums to maintain moisture, and then shipped and stored by OMNI for use in testing. TPT reported that lump and stoker coal had sulfur contents of 0.086 and 0.101 weight % S (dry basis), respectively. Fuel moisture contents for the eight coal test charges measured by OMNI immediately prior to testing ranged from 11.20-33.50%.

With regard to $PM_{2.5}$ emissions, coal emission factors were (unlike cordwood emission factors) somewhat variable depending upon the device tested, wet vs. dry fuel, fuel form factor, firing rate, and other test conditions. For lack of any information from AP-42 on residential coal burning, the emission factors used to develop the Fairbanks inventory were taken from the OMNI test results, using the average of all valid tests at low firing rate (which is close to the expected heating season average firing rate). These and other OMNI emission factors suggested for use in the SIP are shown in Tables 2-2 and 2-3, below, for wood-burning and other burning, respectively.

2.4 Emission Factors for Other Fuels, Appliances and Pollutants

The main focus of the Fairbanks SIP, OMNI's study, and Sierra's analysis has been $PM_{2.5}$; however, in addition to measuring $PM_{2.5}$ and selected constituent species, OMNI measured and developed emission factors for SO_2, volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxide (NO), nitrogen dioxide (NO_2), NOx, and NH_3.

For those cases where the OMNI study provided more specific and applicable measurements than what is available from AP-42, Sierra has recommended the use of the

Table 2-2 Selected $PM_{2.5}$ Emission Factors for Wood Burning Recommended Use in Alaska $PM_{2.5}$ SIP		
Fuel &Appliance Types	**Emission Factor (lbs/ton, db)**	**Data Source**
Fireplace, no Insert	34.6	AP-42, Table 1.9-1; for SO2, OMNI fuel S for spruce gave emission factor identical to AP42
Fireplace with Insert – non-EPA Certified	30.6	Assumed equal to uncertified woodstove emission factors
Fireplace with Insert ,EPA Certified, non-Cat	12.0	AP-42, www.epa.gov/ttnchie1/ap42/ch01/related/woodstoveapp.pdf, Table 3 for PM emission factors,
Fireplace, With Insert – EPA Certified, Cat	13.0	AP-42, www.epa.gov/ttnchie1/ap42/ch01/related/woodstoveapp.pdf, Table 3 for PM emission factors
Woodstove - Non-EPA Certified	8.17	Avg. of OMNI runs 14 and 15, conventional wood stove, spruce and birch, low firing rate
Woodstove - EPA Certified Non-Catalytic	5.0	Avg. of OMNI runs 5&6 for birch&spruce EPA (noncat) woodstove at low firing rate
Woodstove - EPA Certified Catalytic	5.6	same as immediately above, except that the OMNI avgs are scaled by the same ratio of cat to noncat (16.2/14.6)
Pellet Stove (Exempt)	3.0	OMNI run #1, pellet stove
Pellet Stove (EPA Certified)	3.0	OMNI run #1, pellet stove
OHH (Outdoor Hydronic Heater) - Unqualified	17.26	Avg. of OMNI runs 30&32, OWHH, birch&spruce, low firing rate
OHH - Phase 1	6.5	Avg. of OMNI runs 9 and 11, spruce&birch, EPA qualified OWHH, low firing rate, but scaled by ratio of Phases 1 and 2
OHH - Phase 2	3.45	Avg. of OMNI runs 9 and 11, spruce&birch, EPA qualified OWHH, low firing rate, but scaled by ratio of Phases 1 and 2

Table 2-3
Selected $PM_{2.5}$ Emission Factors for Heating Types Other than Wood Burning Recommended Use in Alaska $PM_{2.5}$ SIP

Fuel &Appliance Types	Emission Factor (units)	Data Source
Central Oil (#2 distillate), Residential	0.457 (lb/1000 gal)	OMNI run#17, SWRI for fuel (lower) heating value, AP-42 for No. 2 fuel oil density
Central Oil (#2 distillate), Commercial	0.457 (lb/1000 gal)	same as above
Portable: 43% Kerosene & 57% Fuel Oil	0.4 (lb/1000 gal)	Emission rates for portable heating devices using kerosene/fuel oil #2 blend assumed equal to central oil (on #2) in absence of actual data
Direct Vent	0.4 (lb/1000 gal)	Emission rates for DV devices using Heating Oil #1 assumed equal to central oil (on #2) in absence of actual data
Natural Gas - Residential	1.9 (lb/10^6 ft3)	EPA, AP-42 Tables 1.4-1 & 1.4-2
Natural Gas - Commercial, small uncontrolled	1.9 (lb/10^6 ft3)	EPA, AP-42 Tables 1.4-1 & 1.4-2
Coal Boiler (bituminous/subbituminous, hand-fed)	8.0 (lb/ton)	Avg. for OMNI runs 21, 23, 37&38, coal stove, wet&dry stoker and lump coal, low firing rate
Waste Oil Burning	5.2 (lb/1000 gal)	OMNI run#18, SWRI for heating value, AP-42 for No. 2 fuel oil density

former, with the two exceptions of SO_2 (discussed earlier) and VOC. For VOC, OMNI's measurements and emission factor are presented on the basis of carbon mass, whereas AP-42 shows mass emissions for TOC (total organic compounds), methane, total non-methane organic compounds (TNMOC), selected organic species, polycyclic aromatic hydrocarbons (PAH), and more. Absent more detailed information about the C-mass fraction of both sources, comparison of the VOC emission factors is problematic. Accordingly, Sierra did not attempt to compare OMNI's VOC emission factors with those in AP-42 and did not recommend substituting the OMNI emission factors for those in AP-42.

2.5 Speciated Emission Profiles from OMNI's Testing

In addition to emission factors, another important deliverable from the OMNI testing was Alaska-specific emission profiles. More specifically, OMNI collected $PM_{2.5}$ samples from its 41 emission tests on Teflon and quartz filters and had those analyzed by its subcontractor RTI. Teflon filters were analyzed for $PM_{2.5}$ mass, common ions, and up to 33 elements. Quartz filters were analyzed for organic and elemental carbon. Based on a review of OMNI data, Sierra recommends that data from the OMNI tests listed in Table 2-4 be further considered for CMB analysis.

Table 2-4
OMNI Tests Recommended by Sierra Research
to be Considered for Use in the Alaska CMB Analysis

OMN Test No.	Summary Description of Appliance, Fuel, and Firing Rate
5	EPA-certified Wood Stove, Birch, Low
6	EPA-certified Wood Stove, Spruce, Low
9	EPA-qualified OWHH, Birch, Low
15	Conventional Wood Stove, Birch, Low
17	Oil Burner, No.2 Fuel Oil (fixed firing rate)
18	Waste Oil Burner, Waste Motor Lube Oil (fixed firing rate)
23	Coal Stove, Wet Stoker Coal, Low
29	Outdoor Coal-Fired OHH, Wet Stoker Coal (auger-based fixed firing rate)
38	Coal Stove, Dry Lump Coal, Low

Based upon above recommendations, the University of Montana generated emission profiles that it then used, along with profiles that it extracted from the EPA's national SPECIATE database,[8] to perform its winter $PM_{2.5}$ CMB modeling of Fairbanks. Results are detailed in a report to ADEC.[9*] As highlighted by Sierra in the excerpt below, UM found a significant difference in the source attribution for mobile sources when using generic EPA source profiles for space heating as compared to OMNI's Alaska-specific profiles:

> *The results of the CMB modeling using source profiles developed by the Environmental Protection Agency (EPA) revealed that wood smoke (likely residential wood combustion) was the major source of $PM_{2.5}$ throughout the winter months in Fairbanks, contributing between 60% and nearly 80% of the measured $PM_{2.5}$ at the four sites. The other sources of $PM_{2.5}$ identified by the CMB model were secondary sulfate (8-20%), ammonium nitrate ((3-11%), diesel exhaust (not detected – 10%), and automobiles (not detected – 7%). Approximately 1% of the $PM_{2.5}$ was unexplained by the CMB model.*
>
> *CMB modeling for winter 2008/2009 was also conducted using Fairbanks-specific space heater source profiles developed by OMNI Environmental Services (sic). Consistent with the previous modeling, wood smoke was identified as being the largest source of $PM_{2.5}$ at all four sites, but identified as contributing less to the ambient $PM_{2.5}$ (51.0% to 73.4%) when compared to modeling using the EPA profiles.* ***Another significant different difference between modeling strategies is that automobiles and diesel exhaust were not identified when using the OMNI profiles. Instead, the OMNI profile for No. 2 fuel oil combustion was identified, contributing from 11.1% to 27.2% of the ambient PM2.5 at each of the four sites"*** (emphasis added)

In other words, when the CMB analysis was supplemented with space heating profiles that are more representative of Alaska, the mobile source attribution dropped from being as much as 17% of the ambient $PM_{2.5}$ to not being identified as a significant source.

Further chemical and isotopic analyses reported by the University of Montana tended to confirm the CMB modeling. These are discussed in both the University's report and a companion CMAQ study report[10] to this report on space heating.

2.6 Comparison with AP-42 and Limitations of the OMNI Study

In contrast to the appliances and fuels selected for their representativeness of Fairbanks in winter and used in the OMNI study, the emissions studies of residential wood burning that underlie EPA's AP-42 average emission factors include, by design, a broad spectrum of devices, fuels, and conditions. Among the variables reflected in the more than 150 studies relied upon by AP-42 are appliance types, models, ages, and technologies; fuel types (including fuels that are uncommon or not used in Alaska); fuel conditions (e.g., moisture content); and form factors (crib vs. cordwood). These variables reflect test

[*] See Appendix C of the referenced report for copies of the emission profiles developed by the University of Montana.

methods and field test conditions that are used throughout North America under a much wider variety of circumstances, not all of which are necessarily appropriate for Alaska. These and other features of the OMNI and AP-42 reported testing are summarized in Table 2-5.

Table 2-5
OMNI's Residential Space Heater Testing for FNSB and Corresponding AP-42 Testing

Features	OMNI Test Program	AP-42[a]
Geographic Representation	Testing specific to interior Alaska appliances/fuels/winter conditions	Testing designed to be representative of average emissions nationwide
Currency	2011 test program, supported by concurrent usage and measurement data (fuel type & moisture, in-use stack temperature monitoring, etc.)	Pertinent sections of AP-42 date from October 1996 or earlier; references dated 1972-2001
Appliances	"Conventional" and "advanced" wood stoves and outdoor hydronic heaters; pellet stove; coal stove; auger-fed coal OHH; fuel and waste oil burners (total: 9 appliances)	Large number and variety of appliances
Sample Size	35 tests conducted	More than 150 studies; hundreds of tests
Fuel Selection	Paper birch & white spruce (most common Fairbanks woods); locally produced wood pellets; Usibelli (Alaska) coal; local Nos. 1&2 fuel & waste oil	Wide variety consistent with nationwide averages (hardwood dominates in most states)
Fuel Moisture	Wood fuels sampled in Fairbanks in winter with typical seasoning & moisture; samples preserved for OMNI testing; wood fuels sampled for moisture prior to testing; resulting emission factors are dry basis	Varies by study ("equilibrium wood moisture" varies by local condition); resulting AP-42 emission factors are dry basis.
Sampling Methods	EPA "Other Test Method 27" for $PM_{2.5}$ (in accordance with EPA proposed changes to method 201A); other EPA methods for gases	Wide variety of primarily EPA methods; most commonly reported as Method 5H or "5H equivalents"

Table 2-5 OMNI's Residential Space Heater Testing for FNSB and Corresponding AP-42 Testing		
Features	**OMNI Test Program**	**AP-42[a]**
Fuel Loadings: Wood Liquid Fuels Coal	 Method 28 for wood fuel amounts & handling but used Alaskan cordwoods rather than Douglas Fir cribwood; No EPA test method; followed manufacturers' operating instructions; extended test duration to collect sufficient PM for analysis No EPA test method for stoves; followed manufacturers' operating instructions	Fuel loadings & form factor vary by study (AP-42 predates Method 28)
Wood Firing Rates	OMNI targeted 35% & max firing rates (OMNI's "low" and "high" firing generally corresponds to Method 28 categories 3&4, respectively; category 3 is predominant mode for "winter season heating")	Varies by study; may be skewed toward "higher than average in-home burn rate"

a. For additional discussion of AP-42 applicability and limitations, see, for example, Houck et al.[6]

As a compendium of generic emission factors, AP-42 is both relatively large in scope and a reliable information resource. However, there are several serious technical challenges to applying the AP-42 average emission factors to wood burning in Fairbanks.

One of the first problems is lack of geographic specificity. AP-42 does not specify the exact mix of wood types that were used for its testing, but it is known from reviews of AP-42 that they are not dominated by either paper birch or white spruce, the two most common types in Fairbanks.

Secondly, as discussed by Houck et al.,[6] the current woodstove population and technology in the U.S. is expected to be much newer than in the AP-42 database. The outdated composition of the AP-42 database is further exacerbated by the fact that wood burning in Fairbanks has increased sharply in recent years due to escalating heating oil prices and some of the nation's highest home heating costs (average about $3,700/year). As a result, the Fairbanks wood burning device population likely consists of more newer-technology, lower-emitting EPA-certified and -qualified wood burning devices than the proportion represented in the AP-42 database. This tends to be supported by the results of the 2012 Fairbanks telephone survey,[7] if stove age is interpreted as a surrogate for the newness of the technology.[*]

Finally, while many of the AP-42 wood appliance tests were reportedly conducted under "field conditions," presumably using representative wood moisture levels for those locations and seasons, it is not known whether the fuel moistures and firing rates in those tests are representative of Fairbanks in winter. In the case of OMNI's testing, OMNI and FNSB took steps to ensure the representativeness of Fairbanks fuel samples by storing samples under conditions designed to conserve sample moisture prior to testing. In addition, OMNI measured and reported the fuel moisture levels (except for liquid fuels) before each test, and they used appropriate heating season average (and selected maximum) firing rates.

One important limitation of the OMNI test program was the number of tests, which was limited by budget constraints to 35. This is far less than the AP-42 sample, which is believed to number in excess of 1,000 tests. However, unlike AP-42, all of the OMNI tests used Alaska-specific fuels, and the appliances tested were specifically chosen by OMNI to be typical of the Alaskan appliance population. Thus, there is a tradeoff between sample size, which favors the AP-42, and data specificity, which favors the available OMNI test results.

A second limitation of the OMNI testing is the lack of replicate tests. However, this was partially compensated by the study design, which provided for multiple tests of individual appliances using different fuels and firing rates. As shown above in Figures 2-1 and 2-2, this approach allowed for suspected systematic variations in emissions to be tested and compared, and the observed patterns in the test results give confidence regarding the variations observed in test results. The figures show, for example, that EPA-certified wood stoves and EPA-qualified OWHHs emit about 70% less and 84% less $PM_{2.5}$ than their non-certified/nonqualified counterparts, and that the patterns of reductions are similar for each fuel and firing rate. (Several apparent deviations from a completely systematic variation, such as higher spruce vs. birch emissions for the non-qualified OWHH in Figure 2-2, are discussed further in the OMNI report.)

Finally, OMNI's study included limited testing to characterize the effect of cold starts, but the results of those tests have not been sufficient to date to quantify the cold start effect. Therefore, Alaska's wood burning and other space heating emission factors, like AP-42 factors, do not include a cold start effect. Similarly, OMNI performed limited testing to characterize the effectiveness of a solid fuel stove catalytic retrofit device, but those test results were also inconclusive.

[*] It should be acknowledged that, despite the generally younger age of the Fairbanks' stove population, some people continue, according to Borough staff, to purchase non-EPA-qualified OWHHs and non-EPA-certified wood stoves.

2.7 Relationship to Other CMAQ Studies

OMNI's measurement study of space heating emissions represents one in a collection of CMAQ-supported studies in 2008, 2009, and 2010.* In support of the OMNI project, CMAQ sponsored both a part-time support task and an expanded monitoring staff support task that assisted in the following activities:

- Collected, prepared, documented, and shipped suitable fuel samples to OMNI;
- Managed the OMNI contract; and
- Through the Air Quality Symposium conducted by the Borough in June 2008, helped to integrate and coordinate the OMNI study results with other efforts, particularly with the CMB Study and the preparation of the emission inventory for the SIP.

The interrelationships of this and other CMAQ tasks are further described elsewhere in a series of consolidated CMAQ reports.[10,11,12]

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* The other 13 CMAQ projects are ADEC Monitoring Support (1st increment), Expanded Monitoring (Saturation) Study, Mobile Monitoring, Data Analysis and Reporting (1st increment), Neighborhood Characterization, Support Expanded Monitoring (2nd increment), Plume Following, Procure Equipment and Deploy APS, Measure Vehicle Emissions, Chemical Mass Balance, Data Analysis (2nd increment), Part-time Support (2nd increment), and Integration/Coordination.

3. SIGNIFICANCE OF THE OMNI STUDY

This CMAQ-supported study by OMNI-Test Laboratories was the first comprehensive, systematic attempt to quantify Alaska-specific emission factors and emission source profiles from space heating appliances and fuels. As such, the most important single fact about OMNI's emission factor and source profile measurements is that they represent Alaska-specific fuels and appliances. Selected results from the study are currently being used to help provide the most scientifically sound and technically defensible basis for the Alaska $PM_{2.5}$ SIP (in progress).

For Alaska, the most important results from OMNI are those for wood burning. Based on the greater specificity and applicability to Fairbanks and the greater amount of current supporting detail available, the OMNI emission factors were selected for use in the Fairbanks $PM_{2.5}$ SIP to represent average emissions for most classes of residential wood burning units, except for fireplaces (which OMNI didn't test and for which AP-42 emission factors are being used). In particular, the average $PM_{2.5}$ emission factors for "low" firing rate tests of birch and spruce (equally weighted) were used to separately characterize the average emission factors for conventional woodstoves and outdoor hydronic heaters, advanced (i.e., more modern) EPA-certified woodstoves, and EPA Phase 2 qualified OWHHs. Additionally, results from OMNI testing with local Alaskan wood pellets were used to characterize pellet stove emissions.

For residential wood burning appliances, which are the major ground level source of directly emitted $PM_{2.5}$ in Fairbanks in winter, OMNI's measured emission factors are significantly lower than the generic emission factors in EPA's AP-42 Emission Factor Handbook. Absent the OMNI data, Alaska would have had little choice under EPA's SIP Guidance but to rely on the AP-42 emission factors, which would have resulted in a significant overstatement of the fraction of the $PM_{2.5}$ emission inventory that is associated with wood burning.

Regarding other pollutants and fuels, the decision to use OMNI's Alaska-specific measurements or EPA's more generic emission factors has depended on different aspects of the original data sources. For example, in the case of NH_3 emissions, the emission factors in AP-42 are based on a tracer method using CO emissions and are considered to be very uncertain, whereas OMNI measured the nitrogen in NH_3 directly, providing, in our opinion, a much more reliable measurement approach and results. In the case of residential coal combustion, there is no AP-42 emission factor, making the choice of OMNI simple. In other cases, there is a more complex tradeoff between sample size, which favors the AP-42 database, and fuel/appliance specificity, which favors using the available OMNI measurement data.[13] In each of these cases, the emission inventory that is being developed for the Alaska SIP makes judicious use of the most reliable, unbiased data sources on a case-by-case basis, and, in several of the most important determinations, test results from OMNI are being used for the baseline and future (projected) emission inventories.

Finally, with respect to emission profiles, the use of OMNI's Alaska-specific space heating emission profiles, rather than generic space heating profiles from the EPA's SPECIATE database, resulted in the attribution of mobile sources to $PM_{2.5}$ emissions being viewed as insignificant compared to an attribution of up to 17% if EPA's generic profile were used. This is a major difference that has important implications for how to prioritize, or in this case not prioritize, pursuit of emission controls for motor vehicles. It also tends to confirm the finding in the companion CMAQ report on characterizing vehicle emissions, that a vehicle emissions model like MOVES—which projects exponentially increasing emissions with temperature and does not account for block heater plug-in and other commonly practiced engine "keep warm" strategies—is likely to seriously overstate vehicular emissions in cold climates like that of Fairbanks.

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11. "CMAQ Support for Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks, Alaska," prepared for Fairbanks North Star Borough by Sierra Research, September 11, 2012.

12. "CMAQ Support for $PM_{2.5}$ Neighborhood Characterization Study in Fairbanks, Alaska," prepared for Fairbanks North Star Borough by Sierra Research, October 17, 2012.

13. See, for example, "Alaska-Specific Emission Factors for Residential Space Heating Fuels and Appliances as a Basis for the Fairbanks $PM_{2.5}$ SIP," prepared by Sierra Research in support of the Fairbanks $PM_{2.5}$ SIP, June 2012.

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sierra research

Report No. SR2012-09-01

CMAQ Support for Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks, Alaska

prepared for:

Fairbanks North Star Borough

September 11, 2012

prepared by:

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Acknowledgement

The success of this study to characterize vehicular emissions in Fairbanks is due in large part to the unwavering support of DEC's Director of Air Quality Alice Edwards, and that of the Director of Fairbanks North Star Borough's Transportation Department, Glenn Miller. Without their continuing support, this project would have gone nowhere. We also wish to acknowledge here Cindy Heil, DEC's conscientious and resourceful contract manager, and Dr. Jim Conner, FNSB's Air Quality Specialist, who afforded the use of essential personnel and equipment at critical stages throughout the study. The most important contributions of many other FNSB staff members, through CMAQ support, are too lengthy to list here but are highlighted in the report.

Report No. SR2012-09-01

CMAQ Support for Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks

Table of Contents

1. SUMMARY

In December 2008, Fairbanks was designated by the U.S. Environmental Protection Agency (EPA) as a $PM_{2.5}$* nonattainment area. When that designation was later formalized by notice in the Federal Register, the State of Alaska was placed on a three-year statutory timetable for preparing and submitting a State Implementation Plan (SIP) to achieve and maintain the national ambient air quality standard for $PM_{2.5}$. In 2009, in anticipation of the formal designation and to support development of the Plan and an effective emission control strategy, DEC sponsored a multi-year study to measure and characterize vehicular emissions of $PM_{2.5}$ and its precursors from mobile sources in Fairbank in the winter. Using funds from the Congestion Mitigation and Air Quality (CMAQ) program, the Fairbanks North Star Borough contributed to that effort by providing the critical staffing needed to conduct vehicle emission testing at the Fairbanks Cold Temperature Test Facility and to perform a range of necessary associated activities. This CMAQ-sponsored staffing support was in addition to substantial facilities support and other in-kind support provided by the Borough.

The subject vehicle emission testing was conducted in the winters of 2009–2010 and 2010–2011 by Sierra Research, and has been documented in a report provided to DEC.[1†] The resulting quantification of vehicle emissions is being relied upon, together with information from the U.S. EPA's MOVES model[2] and results from the EPA-sponsored Kansas City vehicle PM emissions study,[3] to formulate the Fairbanks $PM_{2.5}$ SIP. More specifically, the subject study has measured and documented the exhaust emissions from a representative sample of light duty gasoline powered vehicles in Fairbanks in winter. Furthermore, the $PM_{2.5}$ emissions inventory which has been developed as a result of the study, has shown that on-road vehicles are the second largest category of $PM_{2.5}$ emissions in the nonattainment area (after residential space heating), contributing 18-26% of directly emitted $PM_{2.5}$ in the vicinity of the State Office Building monitoring site and a similar fraction near the North Pole site.

The current report provides background on the Alaska wintertime vehicle characterization study and the CMAQ-sponsored FNSB staff contributions to it. The major elements of the CMAQ-funded portion of the vehicle characterization study were as follows:

- Staff support for dynamometer testing of light-duty gasoline vehicles;
- Staff support for collection of instrumented vehicle data for determining state of engine warm-up in Fairbanks; and
- Staff support for on-road "plume following" that included sampling of plumes from six dynamometer-tested vehicles and of more than 1000 plumes from randomly selected

* "$PM_{2.5}$" refers to fine particles having an aerodynamic diameter smaller than 2.5 microns.
† Superscripts denote references provided in Section 6.

on-road vehicles of a wide range of sizes and types (vehicle plume measurement using a "sniffer"* vehicle).

A separate report ("CMAQ Report for Neighborhood Characterization Study") describes neighborhood ambient sampling by a sniffer vehicle (conducted before and after the plume following highlighted above and described further herein) and by a mobile (re-locatable) air monitoring system.

The remainder of this report provides background on vehicle contributions to the wintertime $PM_{2.5}$ problem in Fairbanks, summaries of how each of the study elements listed above was conducted and how the results improved understanding of the role of vehicle emissions, identification of how CMAQ support contributed to the current study, and the significance of the vehicle characterization study in supporting a technically sound and defensible $PM_{2.5}$ SIP for Alaska.

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* "Sniffer" refers to a vehicle that is instrumented to sample outside air while driving and is able to perform on-the-fly ambient pollutant measurements every few seconds.

2. BACKGROUND

Fairbanks has been collecting measurements of $PM_{2.5}$ at its downtown monitor for more than 20 years. Those measurements show a distinct seasonal pattern of elevated concentrations during both summer and winter months. Large uncontrolled wild fires are the principal cause of the elevated summer values. The causes of the elevated winter values are more complex and include severe meteorology (i.e., low wind speed, low mixing depth heights, and arctic winter temperatures), which limits dispersion potential; the combustion of large volumes of fuel for space heating (primarily high sulfur distillate fuel oil, wood and relatively low sulfur, low BTU coal); and poorly understood atmospheric chemistry that promotes secondary particulate formation. Collectively, these factors have caused the Borough to routinely exceed the more stringent 35 $\mu g/m^3$ National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ that EPA established in 2006, and resulted in Fairbanks being designated as a $PM_{2.5}$ nonattainment area that is required to develop a State Implementation Plan (SIP), which documents the control strategies that will be implemented to demonstrate attainment of the $PM_{2.5}$ standard.

The first step in developing a SIP strategy is to determine the relative contribution of the emission sources to the elevated concentrations. However, initial studies using Positive Matrix Factorization, UNMIX, instrumented vehicle measurements, and monitoring correlation, provided a wide-ranging and conflicting picture of the motor vehicle contribution to elevated $PM_{2.5}$ concentrations[*] and indicated that additional information was needed to resolve this issue.

Another approach that could be used to assess the relative contribution of motor vehicles to the level of directly emitted and related precursor emissions of $PM_{2.5}$ (which is a standard approach in air quality management) would be to construct an overall emissions inventory for Fairbanks. An examination of the available motor vehicle emission factor models, however, showed that they did not well represent winter conditions in Fairbanks. MOBILE6.2, the EPA-approved motor vehicle emission factor model at the time, did not include temperature correction factors for $PM_{2.5}$. This finding conflicted with results of testing programs conducted in Fairbanks in the mid-1990s[4] and more recently by EPA for its Kansas City study,[3] which reported that directly emitted $PM_{2.5}$ emissions increased exponentially as ambient temperatures decreased (i.e., PM doubled for every 20ºF drop). Therefore, MOBILE6.2 as it was then configured could not be used reliably to quantify wintertime $PM_{2.5}$ levels in Fairbanks.

While this problem was addressed in MOVES (EPA's Motor Vehicle Emission Simulator), the successor model to MOBILE6.2, there is an additional concern that the logarithmic $PM_{2.5}$ temperature correction factor applied to gasoline vehicle $PM_{2.5}$ emissions may greatly overstate

[*] Contemporary estimates in 2008, for example, of the motor vehicle contribution to $PM_{2.5}$ during winter episodes varied from less than 5% (Sierra PMF study) to 35% or more (e.g., UAF correlation study).

the vehicular emissions because it does not account for the impacts of block heaters, which are universally employed in Fairbanks at ambient temperatures below -20ºF. Since block heaters impact several of the factors identified in the Kansas City study that influence the rate of $PM_{2.5}$ formation in gasoline vehicles (e.g., enrichment during cold start, time to catalyst light-off, etc.), it was expected (and later confirmed by the subject study) that use of block heaters would greatly diminish the impact of ambient temperature on directly emitted $PM_{2.5}$ levels. Furthermore, almost all of the winter testing conducted in the EPA's Kansas City test program, which served as the primary source for EPA's estimates of PM emissions for MOVES, was at ambient temperatures above 20°F, whereas most $PM_{2.5}$ exceedances in Fairbanks occur when temperatures are below 20°F. Discussions between Sierra and EPA staff in Ann Arbor, Michigan responsible for the development of MOVES confirmed these concerns and acknowledged that a precedent for addressing the impacts of Fairbanks-specific vehicle operating conditions (i.e., use of block heaters, extended cold start idle, and moderate winter driving) was established in the creation of AKMOBILE6 and needs to be addressed in MOVES.

Previous testing programs conducted in Fairbanks collected data quantifying the impact of block heater operation, extended idle, and diminished winter acceleration rates on hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx) emissions. An analysis[5] of those data showed that block heaters reduced overall trip CO by 43.8%. It also showed the HC levels were reduced by 44.4% and NOx levels by 6.4%.

Recognizing that winter operating conditions in Fairbanks impact $PM_{2.5}$ emissions, the State sought to enlist EPA participation in vehicle testing programs to capture these effects, but efforts were unsuccessful. Therefore, to address the gaps in then-current knowledge and to provide a sound basis for estimating vehicular emissions in its Fairbanks $PM_{2.5}$ SIP, DEC issued a competitive procurement entitled "Characterize Vehicular Contributions to $PM_{2.5}$ in Fairbanks, AK."[6] The contract was awarded to and emission testing work was carried out by Sierra Research. The remainder of this report discusses that DEC-sponsored study and the critically important role of the Borough's CMAQ-sponsored FNSB staff support for elements of that study.

2.1 Characterizing Vehicular Contributions to $PM_{2.5}$ in Fairbanks

The main purposes of the vehicle emission characterization study were as follows:

1. To determine the extent to which motor vehicles contribute to the existing $PM_{2.5}$ problem in Fairbanks, Alaska;

2. To determine, for a representative sample of light duty, gasoline powered vehicles in Fairbanks, the effects of low temperatures and plug-ins upon $PM_{2.5}$ emissions;

3. To measure on-road $PM_{2.5}$ emissions through a plume-following study;

4. To determine the typical state of warm-up at engine start for on-road vehicles; and

5. To determine whether the U.S. EPA's MOVES emission model will properly represent emissions under wintertime conditions in Fairbanks, or whether it may need "adjustments."

The study consisted of four main elements: chassis dynamometer testing of more than 30 vehicles, on-road sampling of more than 1,000 vehicle plumes using an instrumented vehicle, sampling and recording of in-use engine coolant temperatures to document the state of engine warm-up, and an examination of MOVES in consideration of the possible need for low-temperature adjustments.

2.2 FNSB's CMAQ Contribution to the Vehicle Characterization Study

As specified in ADEC's RFP, FNSB provided 40-60 hours per week of FNSB assistance during the dynamometer study.

Details of the dynamometer study and on-road plume following, with particular emphasis on the CMAQ-sponsored staff support, are presented in the following section.

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3. DYNAMOMETER AND STATE OF ENGINE WARM-UP TESTING STUDY

This section documents the major FNSB staff contributions through CMAQ funding to DEC's vehicle characterization study. The dynamometer testing portion of the vehicle characterization study consisted of two winter seasons of measurements, a pilot study and a main study, as described below. The corresponding testing work—including preparation, execution, and analysis of results—is described in greater detail in separate report volumes by Sierra Research, as cited below.

3.1 Pilot Dynamometer Study

The first season of dynamometer testing, 2009–2010, may be characterized as a "pilot study" in the sense that only six carefully selected vehicles were tested. Details of the study design, equipment, procedures, analysis and results are provided in Volume 2 of the study report.[7]

3.1.1 Purposes

The main purposes of the pilot study were as follows:

1. To upgrade the Borough's Fairbanks Cold Temperature Test Facility to provide dilution-tunnel based chassis dynamometer measurement of exhaust $PM_{2.5}$ sampling;

2. To test a selected sample of vehicles to determine the impacts of temperature and plug-in upon $PM_{2.5}$ emissions for the same vehicle at different ambient temperatures; and

3. To assess how well the measured Fairbanks test results compared to emission estimates from the U.S. EPA's MOVES emissions model, with particular interest in ambient temperature effects and Alaska wintertime driving behavior.

3.1.2 CMAQ Support

Upgrading of the Fairbanks Cold Temperature Test Facility was carried out by Sierra Research, with assistance from Bob Wells and Dave Herring of the FNSB Heavy Duty Maintenance Shop, who provided expert support with dynamometer maintenance and other test cell support. (See Table 4-1 in the next section for a summary of FNSB staff support). Borough staffer Jeremy Bahr ably constructed a custom filter equilibration chamber to specifications provided by Sierra. Highly accurate filter weight measurements were required to accomplish vehicular PM emission tests in accordance with Federal Test Procedures, and the chamber was required in order to stabilize filters with respect to temperature and humidity prior to weighing them on a Sartorius tenth microgram balance. The balance was positioned on a high mass, low vibration pedestal in the environmentally controlled chamber, along with an electronic deionizer.

All test vehicles were registered in FNSB and recruited through an email inquiry to Borough employees. Vehicle recruitment was arranged by Borough staffers Kelly Shaw and Todd Thompson. Shaw, who is the former vehicle inspection and maintenance inspector for the Borough, also arranged for and prescreened all candidate vehicles (to ensure safe testability and to help ensure reasonably typical vehicles for the "normal" vehicle sample) prior to acceptance into the test program. Acceptance required that owners sign a participation agreement that was drafted by Sierra in consultation with the Borough, and coordination and collection of those agreements was done by Borough staff. Seven vehicles were accepted into the pilot study, with one of those serving as a standby (it was not needed).

Four of the seven vehicles were characterized *a priori* as "normals"—i.e., average mileage for their age (model years 1995 to 2007, and mileages ranging from 21,000 to 119,000), no fault codes set, and no known defects that might result in abnormal PM emissions. Two other vehicles were deliberately chosen as suspected high emitters having high mileage (>200,000 miles), known major defects, and visible smoke. Of the two high emitters, one was a relatively old (MY 1984) carbureted pickup having a strong smell of unburned gasoline and obviously incomplete fuel combustion. The second was a newer sedan (MY 1990) that had two defects induced (removal of the catalyst and enrichment of the fuel mixture).

The pilot testing program was conducted over 13 testing days in February 2010, during which the start of test ambient temperatures ranged from -24°F to +23°F. Each vehicle was tested with and without prior overnight block heater ("plug-in") operation and/or 5-minute warm-up idle (both of which are customary for overnight outdoor soaks in Fairbanks during the winter but were specific DEC objectives for the test program). In addition, each vehicle was tested when ambient soak temperatures were in the range of +20 < T(ºF)< 0 and then again at 0º < T(ºF) < -20. Thus, each vehicle was tested (nominally) 12 days in all, and each vehicle-day of testing included one cold start and one hot start. As prescribed by DEC, driving followed the Alaska Drive Cycle,[*] which is designed to be representative of Alaska winter driving.

One additional element performed at the end of all the dynamometer testing was the on-road sampling of each of the dynamometer-tested vehicles. This was conducted by Sierra with the support of several Borough staff members, including drivers (Sierra researchers and other private individuals are not permitted to drive Borough vehicles), on-board record keepers, etc. This element was designed to test and demonstrate the capability of an on-road vehicle monitoring system to measure the in-plume emissions behind normal emitters and high emitters and distinguish the difference. This effort to sample both types of vehicles was, in fact, successful in that acceleration plumes from both types of vehicles could be distinguished from background and from each other, and in this way could be used to distinguish high and low emitters on road, as discussed further in the CMAQ saturation study report.

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[*]The 816-second long Alaska Drive Cycle (ADC), has a cold start, soak, and hot start test phase, somewhat analogous to the LA4 cycle used in the Federal Test Procedure.

Testing was conducted six days per week. The dynamometer driving and other dynamometer test cell activities for the pilot study were shared by the four assigned Borough staff members with assistance from two DEC staff members (Missy Jensen and Joan Hardesty). Most of the test crew staff members had participated in one or more similar vehicle exhaust emission measurement campaigns in earlier years, and all test crew members alternated hours and days to provide the necessary support each day.

Following refresher training about test cell driving and safety, the test crew performed an assigned list of duties including the following:

- Receiving and checking out vehicles (fuel level, tire pressure, initial cosmetic damage, etc.);
- Positioning soak vehicles with plug-in as required;
- Moving (i.e., pushing) test vehicles into place and securing in the test cell;
- Assisting in vehicle alignment and cleaning tire treads to remove ice and snow;
- Positioning, attaching, and configuring testing equipment;
- Observing tests and assisting the driver as needed;
- Detaching and removing test vehicles and equipment after the test; and
- Completing documentation as needed.

For drivers, there was the additional step of reviewing the driving results with Sierra's test manager, reporting any false starts or stalls, and reviewing any drive trace speed violations.

When the testing portion of the study was completed, test data were analyzed by Sierra and Sierra's subcontractor Rincon Ranch Consulting.

3.1.3 Results

The main findings from the dynamometer pilot study are listed below.

1. Based on the testing in Fairbanks of a sample of four gasoline-powered "normal emitters" in the winter of 2009–2010, $PM_{2.5}$ emissions for the Cold ADC increased exponentially with decreasing ambient temperature; however, the temperature sensitivity of ADC emissions was not as great as that reported in EPA's Kansas City Study using the LA92, which is a different driving cycle with a shorter initial phase. For the Fairbanks vehicles, which were tested over a temperature range of moderate winter temperatures (by Fairbanks standards), $PM_{2.5}$ emissions increased 31% for every 10°F drop in temperature (ambient temperature coefficient of -0.0268). Notably, the derived temperature coefficient for the Cold ADC of -0.0268 (standard error = 0.003) matched that found for the 32-vehicle sample in the main study in 2011, -0.0233 (0.0047), as reported in Volume 1. By contrast, the Kansas City Study reported a $PM_{2.5}$ emissions increase of 58% (nearly twice as much) for the same temperature drop (temperature coefficient of -0.0456). Considering the uncertainties of the two studies (±0.0084 and ±0.0052, respectively), the temperature sensitivity of $PM_{2.5}$ emissions from the sample of Alaskan vehicles when driving the Cold ADC is significantly lower than that of the cold FTP when the EPA's Kansas City results are extrapolated down to the full temperature range of the Alaska testing.

2. For the warm ("hot start") phase of testing, Fairbanks (and KC) vehicles showed, as expected, much lower base emissions than the cold start phase. However, the testing of "normal emitters" in Fairbanks showed no residual influence of ambient temperature in the hot phase, whereas KC testing showed a temperature sensitivity coefficient of -0.0318±0.0028, which predicts an increase of 37% in hot running emissions for every 10°F decrease in temperature (assuming that the KC temperature coefficient can be extrapolated to the colder range of Alaska winters). Although the reasons for this difference are not known, it should be noted that the Fairbanks testing was completed within a period of approximately one month, whereas the KC testing was conducted in a summer phase and a later winter phase—between those times, test vehicles were returned to customer service, different fuels could have been used, and other changes may have occurred.

3. Based on Fairbanks winter test results, block heater plug-in during overnight soak and a 5-minute warm-up idle after engine start (which together are the common practice for vehicles parked out of doors overnight or for extended periods in Fairbanks in winter[*8]) reduced cold start $PM_{2.5}$ emissions by 74%. The incremental effect of combining warm-up idle with plug-in was to diminish the effectiveness of plug-in alone[†] (there was 80% reduction for plug-in alone). None of these effects is considered in MOVES,[‡] despite the fact that at temperatures below about -20°F, most gasoline vehicles will not start without assistance, and such starting is not even attempted in normal winter operation in Fairbanks.

4. Based on the Fairbanks winter test results, a series of modeling equations were developed to predict average $PM_{2.5}$ emission factors. This emissions modeling approach calculated Cold and Hot ADC base emissions of 111 and 6 mg/mi, respectively, for "normal emitters," and of 561 and 161 mg/mi, for Cold and Hot ADCs from "high emitters." For the Cold ADCs, the base emissions were adjusted to account for the following factors: effective temperature (using an exponential factor), ambient temperature, and (where applicable) warm-up idle and plug-in. In addition, a model-year-based age correction was applied for cold start of normal emitters, and fuel system-based corrections (carburetion vs. fuel injection), both hot and cold, were applied for high emitters.

5. Due to the ambient temperatures that prevailed at the time of plug-in testing, the plug-in benefit was measured only at temperatures close to zero. In an effort to fill the gap in assessing block heater effectiveness at lower temperatures, a coolant temperature-based "engineering model" was developed using "CarChip" data from just two (normal emitter) vehicles. The resulting modeled emissions estimate of the average emissions reductions from plug-in was consistent with data from all four normal emitters.

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[*] The use of radio-based remote start devices, locally referred to as "autostarts," is common in Fairbanks in winter to facilitate warm-up idle. Five- to ten-minute warm-up idles are most common.

[†] It is <u>not</u> normal practice in Fairbanks during the wintertime to drive a vehicle after an overnight or extended soak without a warm-up idle, even when using a block heater.

[‡] Subsequent to the preparation of Sierra's report, EPA published an updated version of MOVES which more readily permits specification of drive cycles for light duty vehicles, thus allowing for the emissions effects of LDV extended warmup idles to be accounted for.

As a secondary objective of the dynamometer study, gaseous criteria pollutants were also measured. However, the data were limited due in part to IM240 system saturation during fuel enriched cold starts and HC analyzer malfunction.*

3.2 Main Dynamometer Study

The main dynamometer testing component of the vehicle characterization study, comprising multiple cold and hot start tests of more than 30 vehicles, was conducted in the winter of 2010–2011. Details of the study design, equipment, procedures, analysis and results are provided in Volume 1 of Sierra's study report.[9]

3.2.1 Purposes

The express purposes of this study were as follows:

1. To determine the extent to which motor vehicles contribute to the existing $PM_{2.5}$ problem in Fairbanks, Alaska;
2. To determine, for a representative sample of Fairbanks vehicles, the effects of low temperatures and plug-ins upon $PM_{2.5}$ emissions;
3. To determine on-road $PM_{2.5}$ emissions through a plume-following study;
4. To determine the typical state of warm-up at engine start for on-road vehicles; and
5. To determine whether the U.S. EPA's MOVES emissions model will represent vehicle emissions properly under wintertime conditions in Fairbanks, or whether it may need "adjustments."

3.2.2 CMAQ Support

The study consisted of four main elements: multiple chassis dynamometer tests of each vehicle in a representative sample of more than 30 vehicles and analysis of results, on-road sampling and analysis of more than 1,000 vehicle plumes using an instrumented vehicle,† sampling and analysis of in-use engine coolant temperatures to document the state of engine warm-up, and an examination of MOVES in consideration of the possible need for low-temperature adjustments. Borough staff, through CMAQ support, had important roles in several of these elements, as described next.

* Both of these problems were addressed, but not until after the pilot study was completed. The problem of intermittent HC and CO analyzer saturation was eliminated by installing isolation amplifiers between the gas analyzer and the analog-to-digital conversion board of the Horiba IM240 system; the HC analyzer malfunction was traced to a plugged capillary tube, which was replaced.

† The "plume following" element of the main study is discussed in the Saturation Study CMAQ report.

The dynamometer testing in the main study was similar in many respects to the Pilot Study and was supported by a comparable Borough staff effort on a weekly basis. The main differences in the testing as related to Borough staff support are outlined below.

- More tests were conducted in the main study, with a sample of 32 vehicles (compared to just 6 in the Pilot Study), although the number of tests per vehicle was smaller (3 per vehicle in the main study vs. 12 in the pilot study). As a result, the main study required 19 days of dynamometer testing compared to 12 days for the pilot study, with a proportionally greater CMAQ staff commitment.

- In the main study, all of the dynamometer driving was done by a single staff person, Kelly Shaw (who was the most accurate driver). Shaw, with assistance from Ron Lovell, also screened all of the test vehicles and handled several unanticipated vehicle problems (e.g., minor vehicle damage and repairs).

- The main study was conducted in two test phases, consistent with the test plan of performing tests of each vehicle at both cold and warm temperatures. This design was used to deploy Carchip data loggers for the test vehicles and obtain information on state of engine warm-up at trip starts (discussed in Section 3.4, below).

As in the Pilot Study, DEC provided additional valuable support as test crew members.

Neither Borough staff nor DEC staff participated in the data analysis or reporting from the main study or other study elements. That portion was done by Sierra and its subcontractor Rincon Ranch Consulting. In addition, for the study of the state of engine warm-up, Sierra analyzed the results from data loggers installed for most of the dynamometer tests.

3.2.3 Results

Findings from the dynamometer-based testing are summarized below.

1. Use of block heaters ("plug-in"), heated garages, and extended warm-up idle for light-duty vehicles are all normal activities and/or practical necessities in Fairbanks in winter that can significantly affect $PM_{2.5}$ emissions. However, examination of these effects, which are critical in Fairbanks but less important in locations in the lower 48 states, was beyond the scope of EPA's Kansas City PM Emissions Characterization Study[10] and of (then current[*]) EPA guidance[11,†] for using MOVES. In addition, the PM emission factors

[*] The most recent release of MOVES allows for more readily specifying extended idle for light duty vehicles, as noted earlier.

[†] On p. 43, EPA states "The temperature adjustments in MOVES are intended to represent the effects on vehicle emissions when the ambient temperature to which the vehicle is subjected is known. There may be factors that cause difficulty in determining the appropriate temperature to apply to the fleet, such as the variation of ambient temperature over the area you wish to model. However, these are issues for guidance on how best to use the model for specific scenarios." This guidance was provided in response to the following comment: "Part of the difficulty with adjusting for Tamb (i.e. ambient temperature effects) in the general fleet may be due to the many vehicle parking options: outdoors, unheated indoors, heated indoors or with plugged in block heater. If a vehicle is parked outdoors, the wind chill factor might also influence cold-start emissions. The test data do not seem to account for all

in MOVES, including the temperature corrections of those emission factors, are derived from measurements made in Kansas City, where the minimum temperature for the testing was +12°F.* That Kansas City minimum temperature exceeds the long-term average monthly temperature in Fairbanks for the months of November through March[12] and is well above the -12°F average daily temperature for $PM_{2.5}$ design day episodes in Fairbanks.[13] Other "low temperature" vehicle PM emission studies used to support or help corroborate MOVES had only a limited number of vehicles and tests; conducted testing down to only about -20 or 0°F; and did not include analysis of plug-in, heated garaging, or warm-up idle. As a result of the above limitations, any modeling of Fairbanks PM emissions using MOVES must necessarily rely upon extrapolations of effects measured at higher temperatures, neglect the effects of plug-in, and/or neglect other real effects that significantly influence emissions. The results from emission testing in Fairbanks in the winter of 2011 (summarized below) confirm that such extrapolation and assumptions are not technically supportable and could result in overestimating the $PM_{2.5}$ emissions from light-duty gasoline vehicles by up to 680%.

2. $PM_{2.5}$ emissions from a "Cold ADC" test, representing a morning cold start, warm-up idle, and drive ("Cold ADC") had an average baseline value of 27.5 mg/mi at an ambient temperature of 20°F. These emissions (assuming no vehicle garaging or plug-in) increased exponentially by 26.2% for each 10°F drop in ambient temperature below 20°F (temperature coefficient of 0.0233). By contrast, the EPA-sponsored Kansas City Study reported a $PM_{2.5}$ emissions increase of 58% (more than twice as much) for the same temperature drop (temperature coefficient of -0.0456).

3. For the warm ("hot start") phase of testing, Fairbanks (and Kansas City) vehicles showed, as expected, much lower base $PM_{2.5}$ emissions than the cold start phase. However, the testing of Fairbanks vehicles showed no residual influence of ambient temperature in the hot phase, whereas Kansas City testing showed a temperature sensitivity coefficient of -.0318±0.0028, which predicts an increase of 37% in "stabilized, hot running" emissions for every 10°F decrease in temperature (assuming that the KC temperature coefficient is extrapolated to the colder range of Alaska winters). While the reasons for the difference are not all known, it is noted that the Fairbanks testing had a much longer first phase (300 seconds warm-up idle plus 816 second ADC = 1,116 seconds) compared to 310 seconds for the first phase of the LA92 cycle used in Kansas City, and the Fairbanks cold starts began with a 5-minute warm-up idle; both of these factors are expected to reduce temperature influence. In addition, all of the Fairbanks 32-vehicle testing was completed within 2½ months, whereas the KC testing was conducted in a summer phase and a later winter phase, between which different fuels could have been used and other changes may have occurred.

4. Based on Fairbanks winter test results, block heater plug-in during overnight soak and 5-minute warm-up idle after engine start (which together are the common practice for

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of these factors." What the reviewer suggested as "options" are not, however, optional at Fairbanks winter temperatures, but instead are required for reliable daily vehicle starts.

* At this and higher temperatures, block heater plug-in is not typically required for gasoline-powered vehicles, and it was not used in the Kansas City Study.

vehicles parked out of doors overnight or for extended periods in Fairbanks in winter*[8]) reduced cold start $PM_{2.5}$ emissions by 74%. Neither plug-in nor warm-up idle of light duty gas vehicles is considered in MOVES, despite the fact that at temperatures below about -20°F, most gasoline vehicles will not start reliably without starting assist, and such starting is not routinely attempted in normal winter operation in Fairbanks.

5. Based on filter-calibrated continuous analyzer measurements from non-plug-in Cold ADC dynamometer drives, most of the $PM_{2.5}$ was emitted within the first two minutes after engine start, i.e., probably before the catalyst "lit off" and the vehicle's emission control system entered close loop operation. In addition to startup, $PM_{2.5}$ emissions tended to "spike" during high power accelerations. Compared to the foregoing two types of events, $PM_{2.5}$ emissions at almost all other times were low for most vehicles, regardless of temperature (this may not be true for "high emitting vehicles").

6. As a secondary objective of the dynamometer study, gaseous criteria pollutants were also measured and results are presented for the temperature dependencies of those emissions.

3.3 State of Engine Warm-up in Fairbanks in Winter

For the Federal Test Procedure, the state of engine warm-up for a cold start test is generally adequately controlled by specifying the temperature range (68° to 86°F) and the duration of the prior vehicle soak. Testing of cold temperature certified vehicles (down to +20ºF) adds complexity to this simple picture, but soak time and temperature together still define the relatively simple implicit specification of the state of engine warm-up for vehicle certification testing. However, in Fairbanks, the widespread use of plugin block heaters and extended idle at low temperatures complicates the relationship of soak temperature and duration and the state of engine warm-up, and it raises significant questions about the applicability of the simple relationship which underlies the cold temperature emission estimates from MOVES.

3.3.1 Purpose

The purpose of this relatively low-cost add-on to the dynamometer test program was to better understand the state of engine warm-up at time of engine start for both the dynamometer-tested vehicles and vehicles in customer service.

3.3.2 CMAQ Support

The study of the state of engine coolant was based on installing five to six data loggers in test vehicles; returning those to customer service (typically for a week or more); and then retrieving the data loggers, uploading the data, and repeating the cycle, which lasted for some months. These data were then combined with similar in-use vehicle data from several years earlier. This entire data collection effort in 2010–2011, including vehicle owner contacts and coordination and signing of participation agreements and delivering compensation, was performed by

* Five- to 15-minute warm-up idles are common in Fairbanks, as is the use of radio-based remote start devices, referred to locally as "autostarts."

Borough staff with CMAQ support, as documented in Table 4-1. Study design, preparation of participation agreements, staff direction, data analysis, and reporting was done by Sierra.

The principal Borough staff members performing this work were Kelly Shaw and Todd Thompson, although test crew members all assisted with installing and retrieving data loggers before and after each dynamometer test.

3.3.3 Results

Based upon a review of earlier telephone survey data, both old and new electronically logged vehicle activity data (including soak times and engine coolant temperature data), ambient temperature measurements at several locations, and coolant and other engine temperature data collected during dyno testing, several observations were made about the state of engine warm-up in Fairbanks winters. The key finding is that, at typical $PM_{2.5}$ design day temperatures, vehicle operators use a variety of "keep warm" activities to avoid most engine starts where the engine is near ambient temperature. By comparison, MOVES assumes that such cold engine starts (which would have the highest "start increments" of emissions) occur regardless of how low ambient temperature drops. This assumption in MOVES conflicts with the evidence of "keep warm" activity in Fairbanks, as outlined below.

1. Plug-in engine block heaters are ubiquitous in the Fairbanks winter vehicle population, and they are widely used when vehicles are parked outside for more than a few hours. This is documented by phone survey data showing that for overnight parking at home, heated garaging is the most common vehicle "keep warm" strategy (used by 57% of phone survey respondents) and plug-in is the next most common (37%). For vehicles parked at work, plug-in (66%) is the most common keep-warm activity.

2. For overnight outdoor soaks (of dyno test vehicles), the average difference between starting engine (or coolant) temperature and ambient temperature was less than 5°F. That is, non-plugged-in vehicles do tend to equilibrate overnight to nearly ambient temperature. In contrast, plugged-in vehicles had engine temperatures that were, on average, 56°F higher than ambient temperature (similar, we expect, to heated garage temperatures).

3. Based on instrumented vehicle data, vehicles in Fairbanks typically exhibit markedly elevated coolant temperatures at engine start after extended soaks compared to what would be expected based on ambient temperature cool-down. For soak times longer than six hours, and for the three ambient temperatures ranges of below -20°F, -20°F to 0°F, and 0°F to +20°F, the average startup coolant temperatures of in-use vehicles ranged from 39°F to 55°F and closely matched that of plugged-in vehicles. (For shorter soak times, the corresponding average coolant temperatures at start ranged from 119°F to 135°F, indicating partially warmed up engines.) These elevated coolant temperatures are almost certainly due to "keep warm" efforts by operators.

4. Instrumented vehicle data suggest that, except for very short soak periods (less than 2 hours), plug-in is used almost universally for engine starts at ambient temperatures below

-20°F. While it is possible to start some newer gasoline-powered vehicles at ambient temperatures below -20°F, this is neither recommended nor normal practice in Fairbanks.

5. Limited instrumented vehicle data indicate that plug-in is not used at ambient temperatures above 20°F. In this temperature range, starting coolant temperatures for all soak durations better matched a cool-down model than a plug-in model. However, this temperature range is above that for most tentatively identified Fairbanks "Design Day" conditions.

3.4 Plume Following Study

In August 2009, as part of its Procurement for Characterizing Vehicle Contributions to $PM_{2.5}$ in Fairbanks, ADEC specified a scope of work[6] that included the following:

> *On-road Emission testing – a plume following study, where on road vehicles are followed by an instrumented vehicle to determine their emissions during on road use.*
>
> *The contractor will design and implement a vehicle plume following study, including quality control/assurance activities. The concept of the study is to capture and analyze on road vehicle emissions during on road use. Proposals should include methodology for the study, including study size, and demonstrate their understanding of the vehicle instrumentation required. The successful contractor will be required to set-up instrumentation, develop a quality assurance project plan, and conduct the study in Fairbanks. The contractor shall assume that some assistance will be provided by the Fairbanks North Star Borough staff. For purposes of the proposal, assume that FNSB will provide one driver and any vehicles needed to be instrumented. Final support assistance will be determined with the successful proposer.*

ADEC's procurement was awarded to Sierra Research, who devised and executed a plan to modify a Borough vehicle for plume sampling, train staff in its use, analyze the resulting data, and prepare a report. That report was provided to ADEC in July 2011.[14]

The main goal of the plume-following study was to gain a better understanding of emissions in Fairbanks winters from vehicles that cannot readily be tested on the Borough's light-duty chassis dynamometer (e.g., medium- and heavy-duty vehicles) and/or for which little information exists on the sensitivity of PM emissions to low temperature (e.g., Diesels).[*]

In the winter of 2009-2010, following the development and successful testing by Sierra Research of its prototype plume following instrumentation in Sonoma County, California, a Borough SUV

[*] Unlike the case for gasoline-powered vehicles, the USEPA's MOVES emission factor model currently has *no* provision for temperature adjustment of Diesel emissions. According to EPA, this is not because they believe there is no effect. Rather, they have insufficient data to quantify the effect.

was equipped with bumper- and roof-mounted cyclones to sample on-road plumes from followed vehicles. Real-time analyzers were installed and used to measure $PM_{2.5}$ and CO_2[*] concentrations; a GPS (satellite-based Geographical Positioning System) provided location; a computer logged and displayed data in real time; and supplemental manual, audio and video data were logged.

3.4.1 CMAQ Support for Vehicle Following in 2009-2010

Following training by Sierra, and under CMAQ funding support, Borough staff operated the sampling vehicle on-road, conducting "plume following" operations over a period of 15 days in February and March 2010, consulting with Sierra on issues that arose, and uploading data regularly. Borough staff also prepared contemporaneous audio notes (necessary for efficient capture of license plates) which they later transcribed and, with the aid of the State's registration database, used to characterize vehicle types. This allowed for Sierra to conduct detailed analyses and comparisons across vehicle and engine types, the results of which are summarized below along with results from on-road plume following of the six dynamometer-tested light duty vehicles from the pilot study.

3.4.2 Results of Vehicle Following Study in 2009-2010

Based upon on-road measurements of $PM_{2.5}/CO_2$ ratios in the exhaust plumes of six vehicles previously tested on a dynamometer and upon a sampling of more than 1,000 plumes from pseudo-randomly selected on-road target vehicles of all types in Fairbanks, several conclusions were reached, as summarized below.

1. An on-road measured plume ratio[†] of 0.215 ug/m^3 $PM_{2.5}$ per ppm of CO_2 during accelerations could be used to distinguish the two "high emitters" from the four "normal emitters" in the previous dynamometer-tested sample of light-duty gasoline-powered vehicles. Thus, it could serve as a threshold to distinguish normal from high emitters.

2. Based on the above threshold ratio and the results from sampling acceleration plumes from a pseudo-randomly selected sample of 630[‡] on-road vehicle plumes, 7.5% of the on-road fleet in Fairbanks would be classified as high emitters.

3. The highest average emission ratio was for heavy-duty Diesel trucks (0.408), closely followed by heavy-duty gasoline-powered trucks (0.326); plume ratios for these two categories were statistically indistinguishable from each other.[§]

4. The second-highest emissions ratio was for Diesel-powered vehicles (0.245), which was about three times that for gasoline-powered vehicles (0.080), ($p \sim 0.00\%$).

[*] Carbon dioxide concentrations provided a "tracer" for combustion plumes.
[†] Five-second ratio of vehicle-emitted $PM_{2.5}$ and CO_2 concentrations after subtracting estimated background
[‡] This represents the subsample whose license plates could be read, thereby permitting exclusion of duplicate counts of the same vehicle.
[§] For heavy-duty Diesel and gasoline-powered trucks, and Diesel buses, fewer than 15 vehicles were sampled; as a result, error bands on the estimated means are wide and the power to discern significant differences was reduced.

5. The average emission ratio for light-duty Diesel trucks (0.202) was about three times that for light-duty gasoline-powered trucks (0.071), ($p \sim 0.00\%$).

6. The average emission ratio for heavy-duty gasoline-powered trucks (0.326) was about 4.5 times greater than that for light-duty gasoline-powered trucks (0.071) ($p \sim 0.00\%$).

7. The average emission ratio for light-duty gasoline-powered trucks was comparable to that for (gasoline-powered) cars and Diesel buses.

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4. SUMMARY OF CMAQ SUPPORT

As described earlier and shown in Table 4-1 (below), Borough staff under CMAQ funding supported the subject multi-year study in a variety of ways. Neither the table nor descriptions are intended to be comprehensive; instead, they are intended to highlight the major functions, which encompass many other duties.

Table 4-1
Summary of Major Activities of FNSB Staff in Support of the Vehicle Characterization Study

Pilot Dynamometer and Plume Following Studies, 2009–2010		Main Dynamometer and Engine Warm-up Studies 2010–2011	
Staff	Duties	Staff	Duties
Bahr	Constructed filter equilibration chamber; served as test crew and driver; on-road driver for Plume Following	Bahr, Falk, Gano, Govoni, Remick, Simpson	Served as test cell crew
Gano	Served as test crew and driver; on-road driver for Plume Following	Lovell,	Served as test cell crew; assisted with vehicle inspections and minor vehicle repairs
Shaw	Assisted in vehicle recruitment; inspected all test vehicles; modified one high-emitting vehicle; test cell manager and driver; assisted with lab maintenance	Shaw	Assisted in vehicle recruitment; inspected all test vehicles; test cell manager; drove for all dyno tests; performed minor vehicle repairs; installed and retrieved data loggers; transferred data
Thompson	Coordinated staff; test crew and driver; assisted in vehicle recruitment; on-road driver for Plume Following	Thompson	Assisted in vehicle recruitment; coordinated staff; served as test cell crew; assisted with data loggers and data transferal
Wells, Herring	Provided dyno and lab maintenance support	Wells, Herring	Provided dyno maintenance support

CMAQ funding from fiscal years 2008 and 2009 supported the winter 2009–2010 dynamometer testing program, which was approximately 2.5 weeks in duration, and the on-road Plume Following, which was about 2 weeks on-road and 2 weeks post-processing. CMAQ fiscal year 2009 and 2010 funding supported the winter 2010–2011 dynamometer testing program, which was approximately 4 weeks in duration.

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5. SIGNIFICANCE OF THE SUBJECT STUDY

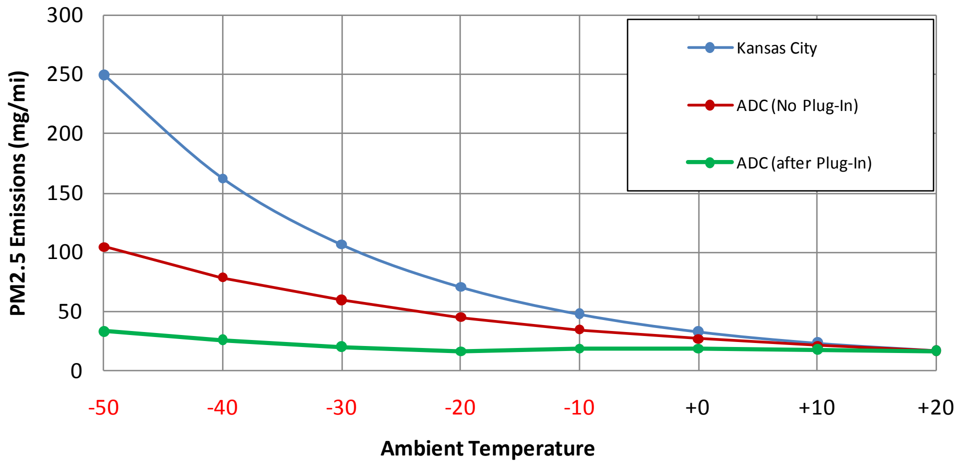
The current study provided DEC and FNSB with a rational basis for the assessing and documenting the contribution of motor vehicles to the Fairbanks winter $PM_{2.5}$ emissions inventory and, thereby, enabled the preparation of an effective and a cost-effective SIP. Absent this research, Alaska would have been forced to rely on highly questionable assumptions about motor vehicle PM emissions and the effects of ambient temperature and block heater plugin upon them. It is not clear whether such an approach could produce a technically sound and defensible SIP. It is particularly informative to note that EPA's MOVES model, which is a critical part of EPA-recommended guidance for estimating vehicular PM emissions for State Implementation Planning, makes no provision for block heater plugin, which is used in Fairbanks in winter almost universally during $PM_{2.5}$ episodic conditions.

Plugin was found in the Sierra dynamometer study to reduce cold start $PM_{2.5}$ emissions by 74%. Even more significantly, the results from emission testing in Fairbanks confirm that extrapolation of MOVES results to Fairbanks temperatures (perhaps the only EPA approvable option for DEC absent the current study) could have resulted in an overestimation of $PM_{2.5}$ from light-duty gasoline vehicles by up to 680%. The effect of both of these default assumptions is shown in Figure 5-1, which is taken from Sierra's report to ADEC.[9] The figure compares $PM_{2.5}$ emission vs. temperature trends as predicted by the Kansas City study[15*] to trends based on the Alaska Drive Cycle (ADC) testing, a driving cycle that is typical of Alaska winter driving. Two ADC lines are shown: no plug-in, and a simple plug-in scenario (0% plug-in at +20°F, 100% at -20°F, and linear interpolation between). In all cases here, the basis for comparison is a 43/57 weighted (Cold ADC/Hot ADC) composite trip of 4.74 mi length.

While the lines diverge markedly at low temperatures, it is important to note that the Kansas City and Fairbanks studies give almost the same fleet-average emission factors at +20°F, which is the temperature regime where both studies overlap (albeit slightly). The close correspondence of the Kansas City and Fairbanks data at the upper range of Fairbanks temperatures shown tends to support the quality of the data from both programs and the fairness of the comparison. However, the Fairbanks measurements pick up below +20°F, where the Kansas City measurements study left off, and indicate that the temperature sensitivity below that is much less than at the higher Kansas City temperature range. Furthermore, the Fairbanks plug-in scenario shows that plug-in usage can hold emissions constant or even force them down slightly when the entire fleet is plugged-in at -20°F.

* It should be noted that the Kansas City emission factor lines shown in the figure are based on an adjusted treatment of temperature sensitivity and the method of forming a composite trip, as discussed in Section 3 of the cited Sierra study. This near-perfect correspondence at +20°F would not result from using the Kansas City PM Study Report, Figures 12 and 13 alone.

Figure 5-1
$PM_{2.5}$ Emissions for Composite Trip (4.74 mi)
ADC and Kansas City Studies



Source: "Characterizing Vehicular Contributions to PM2.5 in Fairbanks, Alaska, Volume 1: Dynamometer-Based Emissions Measurements, Vehicle Keep-warm Activities, and MOVES Analysis," Sierra Research, July 2011.

Thus, the use of unadjusted MOVES emissions estimates would likely have resulted in motor vehicle emissions being substantially overestimated. Furthermore, subsequent emission inventory analysis by Sierra indicates that the resulting error from using unadjusted MOVES emission estimates could have falsely indicated motor vehicles as the major source of $PM_{2.5}$. That conclusion would have radically undermined any attempt to mitigate the true major source category, which is residential space heating. Most likely, it would have also resulted in years of both unmitigated, potentially harmful population exposure to excessive ambient $PM_{2.5}$ concentrations and costly, unnecessary, and ineffective control measures for vehicles.

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6. REFERENCES

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Cold Climate Housing Research Center

CCHRC

Heating Appliance Operation Survey

Colin Craven

June 30, 2010

Report prepared for
Sierra Research

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Introduction

Current practices in modeling the air pollutants resulting from burning firewood and heating oil in the Fairbanks airshed rely on a proxy for heating appliance use frequency based on heating degree days. However, it is likely that patterns for wood burning are influenced by other factors, such as when the occupants are away from home. Similarly, oil-fired heating appliances may not follow a regular run-time pattern based on ambient air temperature because energy conservation devices can cause a more irregular run-time pattern.

The primary objective of this project was to collect data for a preliminary investigation of heating appliance use patterns in the Fairbanks vicinity. CCHRC monitored twelve homes to determine the hourly frequency of wood and oil heating appliance use over the course of approximately one month during late winter. More than fifty willing survey participants were identified in a telephone survey conducted by Hays Research on behalf of Sierra Research in late January 2010. Seven of the twelve households were picked from this list of willing participants. The remaining five were located by CCHRC informally to include heating appliances that were not included or found in the aforementioned telephone survey. Because of the small number of homes in this survey, the resulting data set is not intended to be a definitive representation of heating appliance use patterns in Fairbanks, but instead a preliminary investigation to provide conditional results and help to guide a more detailed study.

A second objective of this project was to determine the amount of wood homeowners were using during the study period. To meet this objective, CCHRC set up a system whereby the homeowners measured the mass of wood used or provided a tally of the number of pieces of firewood burned during the study period.

Survey Methods

Household Selection

Three types of residential space heating were covered in this project: homes using heating oil only, wood heat only, and mixed use of heating oil and wood. Because no households in the survey heated exclusively with wood, the “wood only” category was defined as households that use wood for approximately 90% or more of their heating demand, as provided in the Hays Research telephone survey. Oil-fired appliances covered by the survey included hydronic boilers, forced-air furnaces and direct-vent appliances. Wood-heating appliances covered by the survey included free-standing wood stoves and fireplace inserts for both the “wood only” and the “mixed use” scenarios. Outdoor wood boilers were provided with a unique category. A summary of the monitored homes is provided in Table 1 below.

Heating Appliance Monitoring

The frequency of operation for oil heating appliances (i.e., run time) was monitored continuously and tallied on an hourly basis using a Runtime DataWatcher from EnergyTools.com. The Runtime DataWatcher was equipped with an AC current sensor placed near the appliance fuel pump which sensed when the pump was running. The duration of the monitoring period for each appliance was approximately one month.

Table 1 – *Summary of Monitored Households and Heating Appliance Categories*						
Category	**Identifier**	**Heating Appliances**	**Weather Station**	**Set Up**	**Completion**	**Days Monitored**
Oil Only	Oil-1	Forced-air furnace	Fairbanks Hills	Feb. 14	Mar. 17	31
	Oil-2	Hydronic boiler	Fairbanks Hills	Feb. 14	Mar. 21	35
	Oil-3	Forced-air furnace	Fairbanks Lowlands	Mar. 2	Apr. 6	35
Wood Only	Wood-1	Hydronic boiler and wood stove	Fairbanks Hills	Feb. 26	Apr. 6	39
	Wood-2	Wood stove and direct-vent air heat	Fairbanks Lowlands	Mar. 5	Apr. 7	33
	Wood-3	Wood stove and electric heat	North Pole	Mar. 9	Apr. 8	30
Outdoor Wood Boiler	OWB-1	Outdoor wood boiler	Fairbanks Lowlands	Mar. 10	Apr. 9	30
	OWB-2	Outdoor wood boiler	Fairbanks Lowlands	Mar. 11	Apr. 7	27
Mixed Use	Mixed-1	Wood stove and oil hydronic boiler	Fairbanks Lowlands	Mar. 3	Apr. 7	35
	Mixed-2	Fireplace insert and oil forced-air furnace	North Pole	Mar. 5	Apr. 7	33
	Mixed-3	Fireplace insert and oil direct-vent hydronic	Fairbanks Hills	Mar. 5	Apr. 7	33
	Mixed-4	Fireplace insert and hydronic boiler	Fairbanks Lowlands	Mar. 8	Apr. 7	30

For two households, heating oil appliance run time was also monitored with a temperature datalogger, EL-USB-TC from Lascar Electronics, equipped with a Type K thermocouple affixed to the exterior of a non-insulated section of exhaust flue. The oil-fired boiler at the Wood-1 household was monitored with both a DataWatcher and a temperature datalogger for a few weeks, providing duplicate streams of data for comparison. The household at Mixed-3, where CCHRC monitored a hydronic direct-vent appliance, first had a temperature datalogger which was then replaced with a DataWatcher. The findings from these appliances are discussed further below.

For wood stoves, the approximate temperature of the exhaust stream or firebox was monitored to determine the use frequency of the heating appliance. All wood stoves were monitored with EL-USB-TC temperature dataloggers equipped with Type K thermocouples. For free-standing wood stoves, the thermocouple was connected to the exterior surface of non-insulated stove pipe. For fireplace-insert wood stoves, the thermocouples were connected to the exterior surface of the appliance close to the firebox. The outdoor wood boiler at the OWB-1 household was monitored by drilling a hole in the insulated chimney section and placing the thermocouple directly in the exhaust stream. The outdoor wood boiler at the OWB-2 household was monitored by placing the thermocouple on the exterior surface of the door to the boiler firebox. Photos of the outdoor wood boiler monitoring points are included in Appendix A.

The only monitoring system repair required during the monitoring period was reattaching a thermocouple to the wood stove flue at the Wood-1 household, which had fallen off approximately half way through the monitoring period.

Firewood Use Estimates

Homeowners estimated the mass of firewood burned during the monitoring period based on one of two systems of measurement and documentation provided by CCHRC. Most survey participants were asked to follow a simple documentation system where the homeowner tracked the date, time, and the number of split or whole logs burned for each loading of the heating appliance. Each participant was provided with a clipboard stocked with spreadsheets set up to log the desired information. Additionally, two survey participants were asked to follow the log count method and also to determine the mass of the firewood burned using a digital scale provided by CCHRC.

Climatic Data

In the spreadsheet containing the monitoring data, CCHRC included a tabulation of the hourly ambient air temperature for each day included in the monitoring period. The air temperature for each of the surveyed homes was determined from a meteorological station chosen based on the proximity and elevation of the station in relation to the surveyed homes. The meteorological station elevation is particularly important due to strong winter temperature inversions. The three meteorological stations chosen are summarized below.

- Fairbanks Lowlands: Fairbanks Airport (PAFA), Elevation 433 ft
- North Pole: MSRGA2 (Small Arms Range), Elevation 488 ft
- Fairbanks Hills: MFAOA2 (College Observatory), Elevation 596 ft

The station representing the ambient conditions at each household is provided in Table 1 above.

Survey Findings

Oil Heating Appliance Monitoring

The Runtime DataWatcher datalogger was simple to deploy and provided data output in a format well suited for the survey needs. The only complication with the DataWatcher system was encountered with the direct-vent hydronic heating appliance at the Mixed-3 household that received fuel from a day tank. The current sensor was placed on the fuel pump for the day tank and registered a signal when the unit ran, however, no data was subsequently recorded during the monitoring time period. In troubleshooting this application with a datalogger technician, we developed two alternatives: selecting a higher sensitivity for the current sensor or using a different current sensor made to attach to wiring carrying AC current. If successfully deployed on the day tank fuel pump, this would provide the total run time of the fuel pump, but not necessarily the run time of the heating appliance itself. Other potential strategies for this type of heating appliances include more intrusive inspection of the appliance components to find an internal pump downstream of the day tank, or using a temperature datalogger with a sensor connected to the exhaust flue.

For the direct-vent appliance at the Wood-2 household, a small forced-air room heater, the pressure pump was easily accessible through an access hatch. This allowed for simple monitoring of the heating appliance similar to larger hydronic boilers and forced-air furnaces.

Wood-Heating Appliance Monitoring

Because of the substantial differences in operation between oil and wood-fired heating appliances, the run time of the two appliance types are fundamentally different. The oil appliances studied used a fuel pump that could be monitored with the Runtime DataWatchers as a binary (“on” or “off”) system. This allowed for a straight-forward tallying of total operation frequency per hour. When monitoring a wood stove using a temperature datalogger, explicit assumptions are required to define what constitutes an “on” and “off” signal. The temperature of the wood stove will increase or be relatively high when it’s in operation and stoked, and decrease as the firewood is depleted or starved for oxygen. Two simple methods of defining the “on” cycle for wood appliances include:

- Assigning a threshold temperature criterion for the minimum “on” temperature,
- Assigning a minimum criterion for change in temperature with respect to time in combination with a threshold temperature criterion.

Once the “on” criterion has been defined, the data can be transformed into a binary signal, therefore allowing for hourly run time assignments analogous to that assigned to oil heating appliances.

For the household at Wood-1 where the oil-fired hydronic heater was monitored using both datalogging systems for several weeks, CCHRC found that the both approaches for defining “on” from the temperature data were successful in replicating the total run time recorded by the Runtime DataWatcher. Specifically, the Runtime DataWatcher recorded that the oil hydronic heater ran for 3.1% of the time between the mornings of March 2 and March 21, 2010. This result can be replicated from the temperature data by defining “on” as a minimum threshold temperature of 139^{o}F, or by defining “on” as requiring a threshold temperature of 180^{o}F or a minimum positive temperature increase rate of 9^{o}F/minute. Because it removes a potentially unnecessary variable, the simpler approach of a single temperature criterion was the chosen method for the spreadsheet of the monitoring data.

Beyond defining the run time for wood appliances, a qualitative examination of the temperature versus time charts included in the monitoring data spreadsheet can illustrate approximate characteristics of wood burning. For example, examination of the two monitored outdoor wood boilers show a marked difference in operational styles. The chart for the data from the OWB-1 wood boiler shows clear cycles of wood burning and return of the wood boiler to approximately ambient temperatures. In contrast, the OWB-2 wood boiler shows a nearly constant temperature throughout the monitoring period. These notably different operational styles are further verified by the wood use monitoring logs: the OWB-2 wood boiler was loaded at regular intervals, whereas the OWB-1 wood boiler was loaded in a more ad hoc manner. In this comparison, recall that the temperature sensor in the OWB-1 wood boiler was placed directly in the exhaust stream and the temperature sensor for the OWB-2 wood boiler was placed on the door to the boiler firebox.

Firewood Use Estimates

One of the two households CCHRC asked to determine the mass of the wood burned as well as the size, shape and number of logs burned provided all the requested information. The other household recorded only the mass of the firewood. This allowed for one opportunity to compare the two methods directly and calibrate the system of estimating wood mass based on its size and shape. Reasonable agreement between the estimated and measured masses was achieved by using the average diameter and length of firewood pieces provided by the homeowner, modeling the volume of split firewood as a half cylinder, the volume of whole logs as a cylinder, and assuming the density of firewood is approximately 35 lb./cubic foot. Because this comparison was only successful for one household, it is unknown how well the estimating system would work beyond this example.

Of the nine households surveyed that burn firewood, four provided all the data requested for the firewood use estimates. Three provided most of the requested information, but left out variables such as the average diameter and length of firewood burned. Two households provided very sparse information that made the firewood use estimates difficult to interpret or unusable.

Given these variable results, CCHRC recommends that future surveys use only a simple mass determination system for wood stove users. Compared to the other costs associated with monitoring appliance use in a household, the added cost of providing a digital scale for each household would not be appreciable. The direct measurement system makes the task more concrete for the homeowner, as only the total mass burned for each firing requires determination. In comparison, counting and describing all of firewood pieces burned is a less certain and more complicated task that requires a description of materials that can vary significantly in shape, size and mass between individual pieces. However, because it is unlikely that a homeowner would be willing to bring the firewood inside for determining its mass, CCHRC recommends using this system for users of outdoor wood boilers. To help obtain better compliance with the estimating system, CCHRC recommends further emphasizing the importance of the firewood use estimates to the survey participants, offering an additional financial incentive, making the spreadsheets simpler to fill out, or a combination of these methods.

Survey Participant Recruitment

Securing the necessary participants for the *Heating Appliance Operation Survey* required a moderate amount of time and effort relative to the small size of the survey. The original intent was to keep the participants limited to the population included in the January 2010 telephone survey conducted by Hays Research. However, since the *Heating Appliance Operation Survey* was designed to include households that heat with outdoor wood boilers and solely with oil-fired appliances, these inevitably lead to the recruitment of participants outside the population from the Hays Research telephone survey. None of the willing survey participants identified from the Hays Research telephone survey fit this description. The Hays Research survey made it easy to locate good candidates for the “wood only” and “mixed use” categories of households because the participants had identified their type of heating appliances and the relative amount each contributed to their home heating needs.

Approximately seven known owners of outdoor wood boilers were contacted by CCHRC to seek their participation in the *Heating Appliance Operation Survey*. The owner of the OWB-1 wood boiler was known in advance of the survey to be interested in studying its operation. Because the prevalence of oil-fired appliances in Fairbanks, the three willing participants for the survey were located informally with no difficulty.

The $100 incentive offered to survey participants seemed to vary from not relevant to moderately helpful in securing participant cooperation. No potential survey participants requested greater sums for participation, and no chosen survey participants turned down the incentive.

Appendix A – Photographs of Monitoring for Select Heating Appliances

Thermocouple placement for outdoor wood boiler at OWB-1.

Thermocouple placement for outdoor wood boiler at OWB-2.

Cold Climate Housing Research Center

CCHRC

Heating Appliance Operation Survey, Phase II
Fairbanks, Alaska

June 30, 2011

A project report prepared by CCHRC for:
Sierra Research

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Contents

Introduction

Current practices in modeling the air pollutants resulting from burning firewood and heating oil in the Fairbanks airshed correlate heating appliance use frequency with ambient air temperatures. However, it is likely that patterns for wood burning are influenced by other factors, such as when the occupants are away from home. Similarly, oil-fired heating appliances may not follow a regular runtime pattern based on ambient air temperature because energy conservation devices can introduce significant variation in the heating appliance runtime pattern.

The primary objective of this project was to collect data on heating appliance use patterns in the Fairbanks vicinity for homes using oil and/or wood heating appliances. This monitoring is the second phase of a study conducted by CCHRC for Sierra Research from February to April 2010. In this second study phase, CCHRC monitored 30 homes to determine the hourly use frequency of wood and oil heating appliances over 6 to 10 weeks from December 2010 to February 2011. Willing participants for the monitoring were identified in a telephone survey conducted by Hays Research Group on behalf of Sierra Research in November 2010. Most of the households monitored were picked from this list of willing participants, however, some were located by CCHRC informally to include households using heating appliances that were not found in the aforementioned telephone survey (e.g. outdoor wood hydronic heaters). The data from this heating appliance survey are not intended as a representative sample of heating appliance use patterns in Fairbanks, but instead as a targeted analysis of specific household heating methods.

Another objective of this project was to determine the moisture content of firewood used by homeowners during the study period. To meet this objective, CCHRC sampled firewood from the 20 households that used a wood heating appliance for part or all of their space heating needs.

Survey Methods

Heating appliances that use oil (No. 1 or No. 2 heating oil) and firewood were monitored in this project. The means by which these fuel sources were used to heat residential homes varied, but can be generally classified as one of the following heating appliances:

- Oil-fired boilers, furnaces, and direct-vent room heaters;
- Cordwood-burning stoves, fireplace inserts, fireplaces, and outdoor wood hydronic heaters.

All heaters used in the participating households were monitored for run time and mass of fuel consumed using methods described below. For example, if a household met its heating demand with a wood stove and an oil-fired boiler, both of the heating appliances were monitored. In each household, the homeowners were asked how they provide hot water, the number of household occupants, the area of conditioned floor space, and if they close off areas of the house in winter.

A participation incentive of $150 was provided as a check to each of the 30 surveyed households at the end of survey period.

A summary of the monitored home categories follows, and a summary of the 30 households monitored is provided in Table 1 below.

Wood Heating Households

This category of households is defined as survey participants meeting 80% or more of their space heating demand by burning wood (based on the Hays Research telephone survey). The remaining 20% or less of the heating demand came from wood or oil, but not other energy sources (e.g. coal, natural gas, wood pellets, or electricity). Ten homes within this category were included in the monitoring, divided into the following subcategories:

- Six households heated primarily by wood stoves,
- One household heated primarily by a wood-burning fireplace and a wood stove,
- Two households heated primarily by outdoor hydronic wood heaters,
- One household heated by a multi-fuel boiler that was primarily run on firewood.

Oil Heating Households

This category of households is defined as survey participants meeting 100% of their space heating demand by burning oil in central heating appliances (boilers or furnaces) or direct-vent room heaters (commonly Toyo or Monitor products). Ten homes within this category were included in the monitoring, divided into two subcategories:

- Eight households heated by central oil-fired boilers or furnaces,
- Two households heated by direct-vent room heaters.

Mixed Heating Methods Households

This category of households is defined as survey participants meeting between 20% to 80% of their heating demand by oil and the remainder by wood. Households identified as using other energy sources (e.g. electric resistance heaters, coal, etc.) for space heating were excluded from the survey.

Ten homes within this category were included in the monitoring, all of which used a central oil system in conjunction with wood stoves, in the following subcategories:

- Six households with central oil and non-catalytic wood stoves,
- Three households with central oil and catalytic wood stoves,
- One household with central oil, a fireplace, and a wood stove.

Table 1 – Summary of Monitored Households and Heating Appliance Categories

ID #	Heating Category	Weather Station	Heating Appliances	Set Up Date	Pick Up Date
1	Mixed	RSQA2	Central oil and non-catalytic wood stove	12/23/2010	2/3/2011
2	Mixed	CW6333	Central oil and non-catalytic wood stove	12/14/2010	1/27/2011
3	Mixed	Mongo	Central oil and non-catalytic wood stove	12/15/2010	2/4/2011
4	Mixed	Mongo	Central oil and catalytic wood stove	12/20/2010	2/27/2011
5	Mixed	CCHRC	Central oil and catalytic wood stove	12/21/2010	2/3/2011
6	Mixed	CCHRC	Central oil and catalytic wood stove	12/22/2010	2/4/2011
7	Mixed	RSQA2	Central oil and non-catalytic wood stove	12/16/2010	1/28/2011
8	Mixed	RSQA2	Central oil and non-catalytic wood stoves	12/17/2010	2/3/2011
9	Mixed	CCHRC	Central oil, wood stove and fireplace	12/21/2010	2/19/2011
10	Mixed	CCHRC	Central oil and non-catalytic wood stove	12/20/2010	2/4/2011
11	Oil, Central	RSQA2	Central oil	12/16/2010	1/27/2011
12	Oil, Central	Mongo	Central oil	12/22/2010	2/8/2011
13	Oil, Central	CCHRC	Central oil	12/17/2010	2/4/2011
14	Oil, Central	CCHRC	Central oil	12/21/2010	2/4/2011
15	Oil, Central	Mongo	Central oil	12/16/2010	1/27/2011
16	Oil, Central	CCHRC	Central oil	12/15/2010	1/26/2011
17	Oil, Central	RSQA2	Central oil	12/23/2010	2/2/2011
18	Oil, Central	CCHRC	Central oil	12/23/2010	2/16/2011
19	Oil, Direct	Mongo	Oil fired direct-vent room heaters	12/16/2010	1/27/2011
20	Oil, Direct	Mongo	Oil fired direct-vent room heater	12/15/2010	1/30/2011
21	Wood	RSQA2	Catalytic wood stove and direct-vent oil	12/16/2010	1/28/2011
22	Wood	CCHRC	Non-catalytic wood stove and direct-vent oil	12/28/2010	2/16/2011
23	Wood	RSQA2	Non-catalytic wood stove and direct-vent oil	12/17/2010	2/24/2011
24	Wood	RSQA2	Non-catalytic wood stove	12/21/2010	2/1/2011
25	Wood	CCHRC	Multi-fuel boiler and central oil	12/16/2010	2/4/2011
26	Wood	RSQA2	Non-catalytic wood stove and central oil	12/24/2010	2/9/2011
27	Wood	Mongo	Non-catalytic wood stove and direct-vent oil	12/30/2010	2/19/2011
28	Wood	CCHRC	Catalytic wood stove and central oil	12/15/2010	2/9/2011
29	Wood, OWB	CW6333	Outdoor hydronic heater and central oil	12/26/2010	2/9/2011
30	Wood, OWB	RSQA2	Outdoor hydronic heater	12/17/2010	1/28/2011

Monitoring Methods

Oil Appliances

The oil burn rates were recorded from the labels on each oil appliance monitored, and homeowners were asked to identify the type of heating oil they use (#1 or #2). Because the direct-vent oil room heaters modulate, the three or four fuel burn rates for these appliances were determined from product manuals available online or from information provided by product distributors.

Central Oil

The frequency of operation for central oil heating appliances (i.e. runtime) was monitored continuously and tallied on an hourly basis using a Runtime DataWatcher (EnergyTools.com) or a Hobo U-9 motor datalogger (Onset Computer Corporation). Both motor sensor dataloggers were equipped with an AC current sensor placed near the appliance fuel pump that detected and logged changes in the pump status (i.e. change to on or off state). Example photographs of the Runtime DataWatcher motor sensor and datalogger are provided in Appendix A.

The Runtime DataWatcher dataloggers were simple to deploy, reliable, and provided data output in a format well suited for the survey needs. In some instances during the monitoring period, the electrical tape holding the motor sensor in place failed partially, causing the sensor to be in proximity of the monitored fuel pump, but not in physical contact. However, because the sensor detects induced current, these instances of sensor slippage did not compromise the completeness of the data sets. In two cases, the sensor fell off and was reattached by the homeowner without causing noticeable gaps in the data record.

The Hobo U-9 motor dataloggers were simple to deploy and reliable. Only one household with a central oil heating appliance was not successfully logged by the Hobo U-9, but this was due to operator error in not correctly initiating the datalogger. The Hobo U-9 data output only included change in motor state (i.e. a binary signal) with an accompanying timestamp. To process this raw data into an hourly runtime similar to the Runtime DataWatcher, CCHRC contracted with Analysis North in Anchorage, Alaska to create a custom conversion program. Each Hobo U-9 output file was used as input for the custom program, creating a new output file that was used as raw data in the spreadsheets provided to Sierra Research.

Oil Room Heaters

The direct-vent oil room heaters monitored have modulating burn rates, therefore while a motor signal could track the runtime for these heating appliances, such data would be insufficient to determine the volume of fuel consumed during the runtime. Accordingly, CCHRC monitored the runtime of these heating appliances by logging the temperature of the exterior surface of the direct vent exhaust flue pipe, between the heater and the wall, using a temperature datalogger, EL-USB-TC from Lascar Electronics equipped with a Type K thermocouple. While tests of this approach before deployment of dataloggers indicated that changes in the heater burn rate would correspond to detectable changes in flue pipe temperatures, this correlation was not reliably observed in the monitoring data from the surveyed households.

The datalogger sampled the flue pipe temperature once per minute, which filled the datalogger memory in approximately three weeks. Because a longer monitoring period was desired, the CCHRC installed two thermocouple dataloggers per oil room heater with one programmed to have a delayed start. The two temperature dataloggers were set up to have approximately one day of overlap in their monitoring periods.

Oil Consumption Monitoring

To provide an aggregate estimate of oil consumption over the monitoring period, CCHRC requested that each homeowner dip their oil tanks at the beginning of the monitoring period, before and after a fuel delivery, and at the end of the monitoring period. Each survey participant was provided with a clipboard stocked with spreadsheets to log the desired information, and several homeowners without oil tank dipsticks were provided with calibrated dipsticks purchased from Greer Tank in Fairbanks. Despite this preparation, several homeowners did not provide the requested information, or the accuracy of the provided information was questionable. One source of uncertainty that was hard to address was for households with below-ground storage tanks of unknown capacity and geometry.

Wood Appliances

Because of the substantial differences in operation between oil- and wood-fired heating appliances, the runtime of the two appliance types are fundamentally different. The oil appliances studied used a fuel pump that could be monitored as a binary system. Except for the direct-vent oil room heaters, this allowed for a straightforward tallying of total operation frequency per hour. The approximate temperature of the wood stove and hydronic heater exhaust stream or firebox was monitored to determine the use frequency of the wood heating appliances. This methodology requires assumptions to define what constitutes an “on” and “off” signal. Sierra Research instructed CCHRC not to perform this data processing, therefore only the temperature data from the wood heating appliance flue pipe or firebox surface was provided.

Wood Stoves

All wood stoves and hydronic heaters were monitored with EL-USB-TC temperature dataloggers equipped with Type K thermocouples sampling at a frequency of once every 5 minutes. For free-standing wood stoves, the thermocouple was typically connected to the exterior surface of non-insulated stove pipe or an exterior surface of the firebox using high-temperature foil tape. Multiple difficulties were experienced with the foil tape detaching from the stove pipe, often leading to a mechanical connection being used instead, as shown in a representative photo in Appendix A. Documentation of these interruptions in the data continuity is provided in the data spreadsheets provided to Sierra Research.

Wood Hydronic Heaters

For one outdoor wood hydronic heater (#30 from Table 1), the thermocouple was connected to the exterior surface of the appliance connected to the firebox. For the other outdoor wood hydronic heater (#29 from Table 1), the thermocouple was connected to an insulated section of the flue pipe and a Hobo U-9 datalogger was connected to a fan motor that serves as a component in the wood combustion process. For the multi-fuel boiler (#25 from Table 1), a thermocouple placed within the flue pipe through a barometric damper, and a Runtime DataWatcher was connected to the heating oil pump. The boiler controls triggered the oil gun to run automatically as a backup to the wood firebox during high load conditions. While the oil was used infrequently during the monitoring period, the exhaust temperature signal does not differentiate the contribution from wood or oil. From the exhaust temperature data, it appears that the oil gun would run concurrently during wood combustion.

Wood Consumption Monitoring

Homeowners estimated the mass of firewood burned during one week of the monitoring period by using a weighing tub and digital scale provided by CCHRC. Each survey participant was also provided with a clipboard stocked with spreadsheets to log the desired information. With the exception of one household that failed to complete the requested week of data recording, and one household that provided suspect data due to high uniformity, this method of documentation was successful. Several survey participants provided more data than the one-week duration requested.

Anomalies

One oil heating household (#13 from Table 1) used a small infrared electric heater set on low during the coldest nights in winter, as well as an additional small electric heater during mornings for 1 – 2 hours. The contribution of these space heaters to the total heating load of the house is unknown. The homeowner did not indicate that electric heaters were used in the Hays Research telephone survey, and there were no indications that electric heaters were used in the household prior to the initial house visit to set up the monitoring systems.

Several of the temperature dataloggers used to monitor direct-vent oil room heaters and wood appliances experienced an explained anomaly at air temperatures around room temperature. For the dataloggers with this anomaly, temperatures recorded would suddenly shift from approximately room temperature to -328 ^{o}F. Fortunately, around room temperature appeared to be the only temperature range that would trigger this anomaly, which corresponds to a state where the monitored heating appliance would be off and cooled. Therefore, in the spreadsheets of processed data, this erroneous signal was converted to 0 ^{o}F for simplicity in graphing temperature versus time. Troubleshoot of the dataloggers and communication with the manufacturer were unsuccessful in diagnosing the origin of the anomaly.

Climatic Data

In the spreadsheets containing the household monitoring data, CCHRC included a tabulation of the hourly ambient air temperature for each day of the monitoring period. The air temperature for each of the surveyed homes was determined from a meteorological station chosen based on the proximity and elevation of the station in relation to the surveyed homes. The met station elevation is particularly important due to strong winter temperature inversions. The four meteorological stations chosen are summarized below. The station representing the ambient conditions at each household is provided in Table 1.

Data Completeness

There are numerous stations in the Fairbanks vicinity that have hourly data, for example, the National Weather Service sites and Citizen Weather Observer Program (CWOP) participants. Many stations have large gaps in their data, including the more official stations (e.g. PAFA at the Fairbanks International Airport). The most complete record of the met stations evaluated was the station located at CCHRC maintained by GW Scientific. Completeness of records during the study period was the primary screening criterion in selecting met stations.

Linking Stations to Surveyed Homes

Based on a qualitative analysis of multiple met stations during the study period, the variance of temperatures between stations in the Fairbanks vicinity at any given time in the winter is more dependent on station elevation than the distance between stations. Therefore, CCHRC decided to associate the surveyed homes with met stations according to elevation. CCHRC's met station was chosen to represent air temperatures for all low-elevation homes (i.e. Tanana valley lowlands). The North Pole homes in the survey are located between met stations that are in the vicinity of Fort Wainwright and a station at Eielson Air Force Base. However, those met stations provide records partially compromised by frequent data gaps. Furthermore, the air temperatures do not seem to vary systematically between Fairbanks, Ft. Wainwright and Eielson stations.

Homes at higher elevations were sorted into bins corresponding to the 3 other met stations at higher elevations. The quality of the sensors at the met stations, calibrations, and station placements are unknown for these 3 sites, but none appear to have obviously erroneous data. The sites are RSQA2 and CW6333 (both CWOP stations), and Bob Hammond's met station labeled "Mongo".

Table 2 – Met Station Selection and Association with Surveyed Homes

Station	Elevation of Station (ft)	Elevation Range for Associated Homes (ft)
CCHRC	440	440 - 559
RSQA2	679	560 - 789
Mongo	903	790 - 1040
CW6333	1171	> 1040

The bins into which the home sites are sorted by elevation are divided by the elevation mid-way between the 4 met stations, as shown in Table 2. Home sites in Fox would be put in the second elevation bin. Given the cold regime in the Goldstream Valley, it is expected that the Fox area would have colder temperatures than those represented by the RSQA2 station. However, there are no other met data available for this area. Similarly, there are no met stations on the west side of town other than a very high elevation site on Ester Dome. CCHRC assumed that temperatures within the Fairbanks bowl are applicable to areas west of Fairbanks, although we have no data to support that decision.

Treatment of Gaps in Temperature Data

Although the CCHRC site has no gaps in the hourly temperature data, the other 3 met stations have periods of missing data. To fill data gaps, several different methods were employed depending largely upon the length of the gap. Linear interpolations between existing data fill short gaps of 8 hours or less. For longer gaps, temperatures for a station were derived from data of one or more of the other 3 stations. The method for these gaps depends on the temperature dynamics for that time period. Sometimes a mid-elevation station's data appeared to be conveniently bracketed by the surrounding stations' data on each end of the gap. In that case, the missing data was supplied by an average of the surrounding 2 stations' temperatures. Data from the second highest station supplied data for missing temperatures at the highest station. In several cases for longer gaps, a simple average or linear interpolation did not appear to adequately describe the temperature regime at a particular station. In those cases, a relation (a weighted average or a simple offset) to other stations' data was calculated.

Both CCHRC and Mongo have hourly data reported on the whole hour. RSQA2 reports in 30 minute intervals at :28 and :58 minutes after the hour. CW6333 reports every 10 minutes (at :04, :14, :24, etc). To match the 4 sites' data, temperature records for RSQA2 and CW6333 were averaged over the hour period surrounding the whole hour.

Firewood Moisture Content

As part of the heating appliance operation survey, firewood was sampled from the homes that used wood-heating appliances to determine its moisture content. Twenty of the 30 homes used firewood. The firewood samples were collected from the stacks in use by the homeowner at the time of sampling.

Sampling and Analysis

Because firewood is highly variable in size, the number of firewood pieces in the primary sample varied. CCHRC aimed to collect 8 to 10 pieces of wood in the primary sample, but for homes with unsplit firewood, the number was often substantially less.

If the firewood storage areas provided adequate access, CCHRC collected the primary sample from a grid across the entire exposed firewood area. If a sampling grid was impractical, firewood samples were collected from the accessible area made available by the homeowner. Each homeowner was provided with an equal amount of properly cured wood to replace the sample volume taken.

After collection, samples of firewood were stored outside CCHRC and kept covered. Because firewood moisture content can vary within different zones of the wood (e.g. sapwood versus heartwood), cross-sectional discs approximately one inch thick were cut from the logs to ensure each zone was represented proportionally in the analysis. Two cross-sectional discs were cut from each log in the primary sample: one from a log end and one from the log center. Therefore, the number of subsample discs were twice the number of the logs in the primary sample. Subsamples were prepared from the primary sample within a few days of sample collection. Subsamples were stored in a sealed plastic bag until analysis, and were analyzed within one hour of cutting or stored outside if a longer subsample holding time was necessary.

CCHRC analyzed all firewood subsamples for moisture content following Method B of ASTM Standard Test Method D4442-07 (*Direct Moisture Content Measurement of Wood and Wood-Base Materials*). This method provides an absolute measure of firewood moisture content on a dry-weight basis. The drying oven used was a Quincy Lab convection oven model 40 GC. The mass balance used was an Acculab VICON with readability to 0.1 g. No attempt was made to differentiate the mass loss of water versus that of any other volatile constituents within the wood samples. All firewood moisture content data presented are on a dry-weight basis. The moisture content results of individual subsamples, per ASTM D4442-07 Method B, are estimated to have a precision of ±1%.

The duration of oven time for each subsample varied based on practical considerations, such as drying overnight during the weekdays versus over weekends. Therefore drying time was not standardized for the subsamples, but was evaluated based on the stability of multiple mass measurements over time. When each subsample had changed approximately 0.5 grams or less in mass from the prior mass determination, the drying was considered complete. This provides a conservative determination of the drying endpoint following Method B of ASTM D4442-07.

Results

The results from the moisture content analysis are summarized in Table 3 below.

Table 3 – Moisture Content of Firewood from Surveyed Homes	
ID #*	**Firewood Moisture Content**
1	25%
2	18%
3	17%
4	27%
5	20%
6	18%
7	33%
8	18%
9	38%
10	20%
21	21%
22	31%
23	24%
24	24%
25	19%
26	32%
27	58%
28	20%
29	21%
30	48%

** - The same designating number as used in Table 1.*

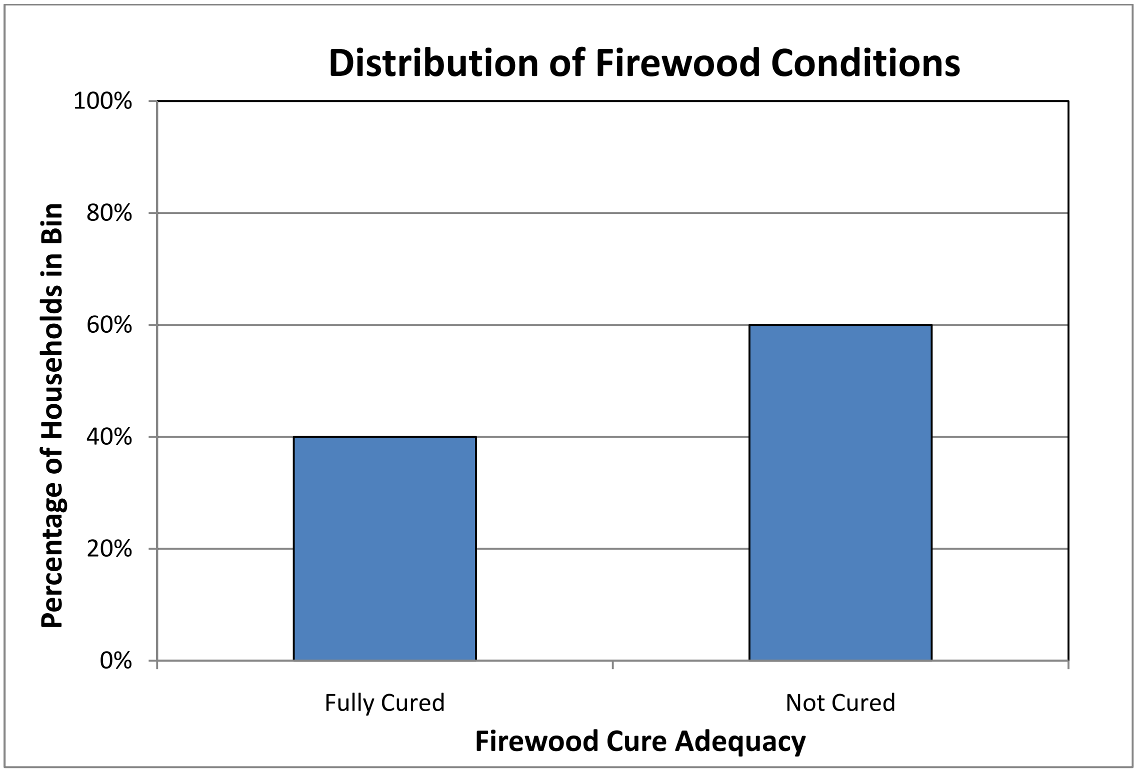

Figure 1 – Percentage of the 20 surveyed households with cured or uncured firewood based on a 20% moisture content criterion.

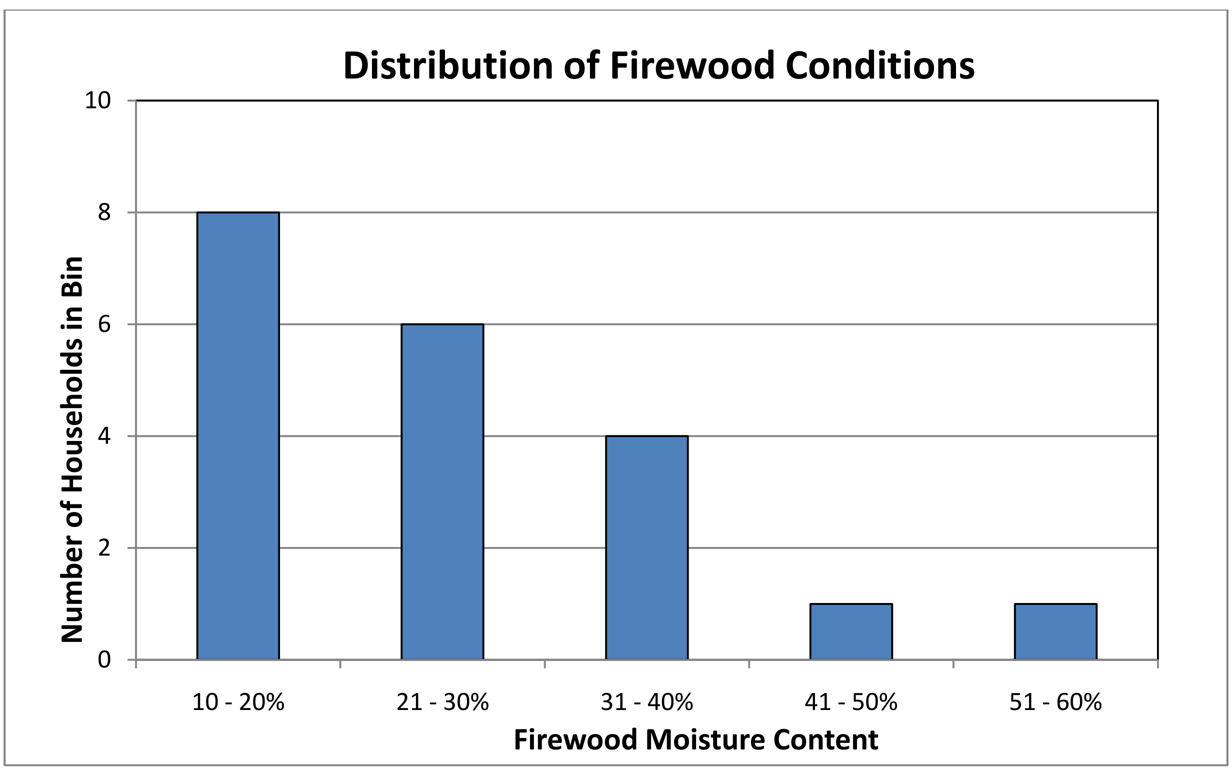

Figure 2 – Distribution of the firewood moisture content for the 20 surveyed households.

Appendix A – Photographs of Heating Appliance Monitoring

Example of a Runtime DataWatcher motor sensor being installed to monitor an oil boiler.

Example of a Runtime DataWatcher datalogger being installed to monitor an oil boiler.

Wood stove flue pipe with a high-temperature thermocouple inserted in the joint between two sections. The thermocouple connects to a datalogger stored in the matchbox holder in the background.

Measurement of Space-Heating Emissions

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1. Introduction

OMNI-Test Laboratories, Inc. (OMNI) was contracted by Fairbanks North Star Borough (FNSB) to measure specific emissions from home heating appliances believed to be contributing to elevated levels of particulate matter smaller than 2.5 microns ($PM_{2.5}$). The objective of the study was to determine real-world emissions produced by devices commonly used in the borough's $PM_{2.5}$ nonattainment area, to use such data to develop source profiles and emission factors which can be used to model air quality within the nonattainment area, to evaluate possible $PM_{2.5}$ mitigation programs for emissions benefits, and to improve overall knowledge about local sources and source apportionment. To that end, nine heating appliances were selected and operated in a normal fashion during testing. This included: (1) tests with both hardwood and softwood cordwood, (2) tests with coal of varying moisture content, (3) tests with heating oils of differing composition, and (4) tests with both higher and lower burn rates. To provide insight into the possible range of emissions produced in the nonattainment area, a variety of appliances, with and without U.S. EPA certification and utilizing different fuels, were selected for the study.

All fuel samples were provided by FNSB and received in good condition. Testing was conducted at OMNI's facilities in Portland, Oregon by Mike Eisele, Lyrik Pitzman, Sebastian Button, Jeremy Clark, and Aaron Kravitz between March 8 and August 18, 2011.

Emissions of total particles (PM), particles with aerodynamic diameters of less than 2.5 microns ($PM_{2.5}$), nitrogen oxides (NO_x), carbon monoxide (CO), total volatile organic compounds (VOC), sulfur dioxide (SO_2), and ammonia (NH_3) were measured. In addition carbon dioxide (CO2), oxygen (O2), temperatures (chimney, room, meter boxes, particulate filters and dilution tunnel), fuel mass, and air and sample flow were measured to support the emission calculations. Moisture, elemental composition, and energy content were also measured for each fuel type. Standard methods were used to the extent feasible for all testing.

A detailed description of the testing program is provided as Section 2. The results of the testing are provided and discussed in Section 3. A summary is provided as Section 4. Real time graphs and analytical laboratory reports are provided as appendices.

2. Testing Program

2.1 Measurements

Measurements deemed appropriate for this study were selected based on consultations between OMNI and Fairbanks North Star Borough staff. Standard sampling methods were used to collect and monitor all parameters. Table 1 lists the methods used and the pollutants measured. Air emission samples were collected from a dilution tunnel. Supporting measurements were made in the heater chimney (stack) and in the surrounding laboratory. Selected background samples were collected from laboratory air. The pollutants measured included:

- Total particulate matter (PM) measured from the dilution tunnel
- Particles less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$) measured from the dilution tunnel
- Nitrogen oxides (NO_x, reported as NO_2) measured from the dilution tunnel
- Carbon monoxide (CO) measured from the dilution tunnel
- Carbon monoxide (CO) measured from the stack
- Oxygen (O2) measured from the stack
- Carbon dioxide (CO_2) measured from the stack
- Sulfur dioxide (SO2) measured from the dilution tunnel
- Ammonia (NH_3) measured from the dilution tunnel
- Total volatile organic compounds (VOC) measured from the dilution tunnel. The total VOC emission factor was collected with a real-time gas analyzer incorporating a flame ionization detector (FID). This value includes methane and most non-methane VOCs, reported as carbon.

Table 1. Compounds, Parameters, Sampling and Monitoring Methods, Collection and Monitoring Devices, Analytical Laboratories, and Analytical Methods

Group	Analytical Compounds	Sampling Method	Collection Device	Analytical Laboratory	Analytical Method*
Particles	Particles less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$)	EPA Other Test Method 27 (In accordance with EPA proposed changes to method 201A)	47 mm Glass Fibre A/E Filter, Teflon coated glass A/E	Research Triangle Institute	Determined by RTI
Gases	Nitrogen Oxides (NO_x)	EPA Method 7E	Chemiluminescent gas analyzer	N/A	N/A
	Carbon Monoxide (CO)	EPA Method 10	Gas filter correlation analyzer	N/A	N/A
	Oxygen (O_2)	EPA Method 3A	Non-dispersive infrared analyzer (NDIR)	N/A	N/A
	Carbon Dioxide(CO_2)	EPA Method 3A	Non-dispersive infrared analyzer (NDIR)	N/A	N/A
	Sulfur Dioxide (SO_2)	EPA Method 6	Pulsed florescence UV analyzer	N/A	N/A
	Ammonia (NH_3)	EPA Conditional Test Method 27	Sulfuric acid-filled impinger series	Columbia Analytical Services, Inc.	EPA Method 350.1
	Total Volatile Organic Compounds (VOC's)	EPA Method 25A	Total hydrocarbon analyzer with flame ionizing detector (FID)	N/A	N/A
Efficiency	Flue Gas CO, CO_2, O_2	CSA B415.1-10	Non-dispersive infrared analyzer (NDIR)	N/A	N/A

*See appropriate laboratory reports in the appendices for modifications to analytical method

2.2 Standardized Methods

ASTM E 2515-07 further specifies the determination of TPM emissions collected in a dilution tunnel and includes specifications concerning the flow rate of the sampling equipment, the construction and proper operation of the dilution tunnel, and calculations for determining the total particulate emissions during a test.

EPA Method 201A pertains to the equipment, preparation, and analysis necessary to measure filterable particulate matter emissions equal to or less than 2.5 micrometers ($PM_{2.5}$).

EPA Method 28 pertains to the certification and auditing of wood heaters. This method prescribes the fueling protocol, conditions, and procedures for determining the particulate emissions and burn rate of a burn event.

EPA Method 28 WHH concerns the measurement of particulate emissions and heating efficiency of wood-fired hydronic heating devices. The method provides specifications for fueling, test facility conditions, and procedures for determining heat output rates and particulate emission rates, and for reducing data.

EPA Method 25A is used in the determination of the total gaseous organic concentration of vapors (i.e., VOCs) which are primarily composed of arenes, alkanes and/or alkenes. This method contains specifications for the type of analyzer to be used, the temperature of the heated sample line carrying gases from the source to the analyzer, the proper location for sampling, the appropriate concentrations for calibration gases, and calculations for determining the average organic concentration in terms of ppm_v as propane.

EPA Method 7E specifies the determination of the concentrations of nitrogen oxides emitted from stationary sources and specifies the type of analyzer and other equipment to be used, sampling locations, gas calibration values, and calculations for determining the average concentration of NO_x.

EPA Method 10 is likewise used in the determination of the concentration of carbon monoxide emissions from stationary sources and specifies the type of analyzer and other equipment to be used, sampling locations, gas calibration values, and calculations for determining the average concentration of CO.

EPA Method 3A is concerned with the determination of oxygen and carbon dioxide emissions from stationary sources and specifies the type of analyzer and other equipment to be used, sampling locations, gas calibration values, and calculations for determining the average concentrations of O_2 and CO_2.

EPA Method 6 prescribes the measurement of sulfur dioxide emissions from stationary sources and specifies the type of analyzer and other equipment to be used, sampling locations, gas calibration values, and calculations for determining the average concentration of SO_2.

EPA Conditional Test Method 27 (CTM-027) addresses the collection of ammonia samples and, in conjunction with EPA Method 17, dictates the assembly and operation of the sample train and metering system as well as procedures for sample recovery.

CSA B415.1-10 specifies requirements for performance testing of solid-fuel-burning heating appliances, including appliance efficiencies via the stack-loss method.

2.3 Sampling Notes

2.3.1 Particulate Sampling

Particulate sampling was carried out in accordance with applicable portions of EPA method 201A. The particulate sampling system relied on a cyclone head attachment on the sample probe in order to sample only particulate smaller than 2.5 microns in diameter ($PM_{2.5}$). The cyclone head was placed in the dilution tunnel and the sample flow was split into 5 branches, each with a filter. The flow rate in each branch was individually controlled. One filter was composed of Teflon, three were quartz, and one was glass fiber. The Teflon filter and one quartz filter were sent to RTI for analysis, one quartz filter was sent to the University of Montana for analysis, and the final quartz filter was retained for OMNI's archive.

The glass fiber filter was used purely for bypass flow. In order to effectively separate particulate matter, a cyclone must be operated within a range of flow rates governed by sample temperature. The Teflon and quartz filters were set to their optimum sample rate and the flow through the glass filter was adjusted to achieve the proper cumulative sample flow.

Figure 1. Cyclone and Filter Assembly

Figure 2. Cyclone Head Detail

2.3.2 Ammonia Sampling

Ammonia sampling was carried out in accordance with EPA CTM 27. The sampling system employed a glass impinger train behind a heated glass fiber particulate filter. The sample was collected in the first two impingers, which were each filled with 100 mL of 0.1 molar sulfuric acid prior to every test run. The sample rate was kept constant and proportional to the dilution tunnel flow throughout testing. Sample recovery was carried out by draining the impingers and rinsing with deionized water. The rinse water was then added to the sample, diluting each impinger's 100 mL to 250 mL.

Figure 3. Ammonia Sampling Probe and Impinger Train

2.3.3 Gas Sampling

Gas sampling system was divided into two trains: one used to measure CO, SO_2, NO, NO_2, and NO_x, and one dedicated solely to VOCs. Each train consisted of a ¼-inch stainless steel probe and a stainless steel 2-micron pore size in-line filter attached to a sample line heated to 215 °F to prevent gas condensation. Air samples for CO/SO_2/NO_x analysis were pumped through a sample conditioner capable of removing water vapor without removing water soluble fractions from the gas sample, resulting in a dry gas sample which has the same composition on a dry basis before and after passing through the conditioner. The dried air was then conveyed to the respective analyzers at pressures dictated by their nominal operating conditions. The VOC analyzer, being an FID detector, required neither an external pump nor a cool, dry gas sample.

The in-line sample filters were replaced as needed, indicated by a drop in sample flow rate to the analyzers.

Figure 4. Probe, In-Line Filter, Heated Sample Line

Figure 5. In-Line Filter Detail

2.4 Operation and Run Notes

Testing adhered as closely as possible to the procedures found in standard EPA methods but for many of the units tested portions of those procedures are not applicable. Therefore, in many instances customized procedures were developed in order to generate repeatable, comparable results while still adhering to the intent of the methods. Table 2 presents a summary of all test runs including which type of common, Fairbanks sourced, fuels were used. The table also indicates which burn setting the appliance was tested at, either “high” or “low” to represent emissions over the range of a unit’s possible controls. Appliances that indicate “single” burn rate operate at the single burn rate that particular unit is capable of, which is typically modulated by a thermostat or other similar devices. For all tests, with the exception of the “cold start” tests, the air controls were set at the beginning of the test, and not changed until testing was completed; see laboratory run notes in Appendix E for exact test settings. A unit-by-unit summary of the testing follows; it covers the operation procedures and deviations from the sample methods used for each run.

Supplementary “cold start” testing was conducted on several of the appliances. These test runs began sampling when the appliance was first lit or turned on, rather than while the appliance was operating. Standard methods were used where possible (e.g. a standard EPA Method 28 pre-burn was performed in the wood stove cold start test), and operation manuals were used where no method was available. Even ignition was achieved with the use of a propane torch for all appliances except the non-qualified hydronic heater, for which a butane lighter was sufficient.

Table 2. Summary of Test Runs

Run	Appliance	Fuel Type	Burn Rate	Hot/Cold Start
1	Pellet Stove	Pellets	Single	Hot
2	EPA Certified Wood Stove	Birch Cordwood	High	Hot
3	EPA Certified Wood Stove	Spruce Cordwood	High	Hot
5	EPA Certified Wood Stove	Birch Cordwood	Low	Hot
6	EPA Certified Wood Stove	Spruce Cordwood	Low	Hot
8	EPA Phase II OWHH	Birch Cordwood	High	Hot
9	EPA Phase II OWHH	Birch Cordwood	Low	Hot
10	EPA Phase II OWHH	Spruce Cordwood	High	Hot
11	EPA Phase II OWHH	Spruce Cordwood	Low	Hot
12	Conventional Wood Stove	Spruce Cordwood	High	Hot
13	Conventional Wood Stove	Birch Cordwood	High	Hot
14	Conventional Wood Stove	Spruce Cordwood	Low	Hot
15	Conventional Wood Stove	Birch Cordwood	Low	Hot
17	Oil Furnace	No. 2 Heating Oil	Single	Hot
18	Waste Oil Furnace	Waste Oil	Single	Hot
20	Coal Stove	Dry Stoker Coal	High	Hot
21	Coal Stove	Dry Stoker Coal	Low	Hot
23	Coal Stove	Wet Stoker Coal	Low	Hot
25	Non-Qualified OWHH	Spruce Cordwood	High	Hot
26	Non-Qualified OWHH	Wet Stoker Coal	Low	Hot
27	Non-Qualified OWHH, Catalyst	Wet Stoker Coal	Low	Hot
28	Auger-Fed Coal HH	Wet Stoker Coal	Low	Cold
29	Auger-Fed Coal HH	Wet Stoker Coal	Low	Hot
30	Non-Qualified OWHH	Spruce Cordwood	Low	Hot
31	Non-Qualified OWHH	Birch Cordwood	High	Hot
32	Non-Qualified OWHH	Birch Cordwood	Low	Hot
33	Non-Qualified OWHH	Birch Cordwood	Low	Cold
34	EPA Phase II OWHH, Catalyst	Birch Cordwood	Low	Hot
35	Coal Stove	Wet Stoker Coal	High	Hot
36	Coal Stove	Wet Lump Coal	Low	Cold
37	Coal Stove	Wet Lump Coal	Low	Hot
38	Coal Stove	Dry Lump Coal	Low	Hot
39	Coal Stove	Wet Stoker Coal	Low	Cold
40	Oil Furnace	No. 1 Heating Oil	Single	Hot
41	EPA Certified Wood Stove	Birch Cordwood	Low	Cold

2.4.1 Pellet Stove

Operation of the pellet stove was carried out in accordance with EPA Method 28. A single run was completed, and no deviations from either Method 28 or any of the proscribed sampling methods were necessary.

Table 3. Pellet Stove Burn Characteristics

Fuel	Run	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Alaskan Pellets	1	6.60	120	2.23	10.5

2.4.2 EPA Certified Wood Stove

EPA Method 28 was used in the testing of the EPA Certified stove. The only deviation occurred in the fuel loads which, while of appropriate weight and length, were not dimensional Douglas fir but rather spruce and birch cordwood, as specified in the proposal. A summary of the fuel loads and burn rates can be found in Table 4. Otherwise, the firing procedures (e.g. preburn length, data collected) adhered to the method. Sampling, likewise, adhered to the methods and procedures specified in Section 2.3. Run 41 utilized a cold start procedure developed for this testing, which for this unit was simply an EPA Method 28 firing procedure, using birch kindling, with emissions sampled throughout the entire burn.

Table 4. EPA Certified Wood Stove Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Spruce	3	High	23.75	83	4.35	16.4
Spruce	6	Low	17.90	210	1.77	16.1
Birch	2	High	17.83	101	3.80	16.6
Birch	5	Low	16.70	248	1.50	15.9
Birch	41	Low, Cold Start	17.30	288	3.14	6.0 Kindling, 16.5 Preburn, 16.4 Test

2.4.3 EPA Phase II Qualified Outdoor Wood-Fired Hydronic Heater

As with the EPA stove, an applicable method was in place for operation of the Phase II outdoor wood-fired hydronic heater (OWHH). Again, this method was followed with the exception of the fuel requirements- the Alaskan fuels were used instead of the specified oak lumber.

In addition to the four high/low runs with birch and spruce, a fifth test was performed with a retrofit catalyst device, which consists of a catalyst and heating element, put on the exhaust gas stack while performing a low burn setting test with birch.

Table 5. EPA Phase II OWHH Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Spruce	10	High	20.78	237	13.31	140.0
Spruce	11	Low	20.32	582	5.48	141.0
Birch	8	High	18.11	243	13.29	140.2
Birch	9	Low	16.40	620	5.29	140.2
Birch	34	Low, with retrofit catalyst	27.90	534	4.98	125.0

2.4.4 Conventional Wood Stove

EPA Method 28 was applicable for the operation of the conventional wood stove tested. Testing was conducted in much the same fashion as with the EPA certified unit, however, controlling the burn rate was problematic. Despite performing high burns at the highest air setting, and low burns at the lowest air setting, very little difference in burn rate was observed. This is likely due to the age of the stove – over time many air leaks developed in the firebox, resulting in uncontrolled air supply to the fire. However, as any non-certified unit still in use in the field would be at least as old as the tested unit, the poorly-controlled air supply was considered typical for a unit of this type, and the data considered acceptable.

Otherwise, sampling was straightforward and as specified.

Table 6. Conventional Wood Stove Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Spruce	12	High	17.38	53	6.49	14.8
Spruce	14	Low	17.70	53	6.24	14.3
Birch	13	High	16.67	40	8.69	14.9
Birch	15	Low	13.95	49	7.26	14.9

2.4.5 Oil Furnace

No EPA standard is in place for oil-burning central air furnaces so the manufacturer's instructions were relied upon for operation. Test duration was dictated by the amount of time needed to acquire a measurable amount of particulate matter on the filters. No modifications to the sampling system or procedures were necessary.

Table 7. Oil Furnace Burn Characteristics

Fuel	Run	Higher Heating Value (BTU/lb)	Duration (min)	Fuel Usage (lb)
No. 1 Fuel Oil	40	19721	886	61.6
No. 2 Fuel Oil	17	19613	519	40.8

2.4.6 Waste Oil Furnace

Testing of the waste oil furnace was conducted in an identical manner to that of the conventional oil furnace. The furnace was run at its single output rate until sufficient particulate had been acquired by each of the sample filters.

Table 8. Waste Oil Furnace Burn Characteristics

Fuel	Run	Higher Heating Value (BTU/lb)	Duration (min)	Fuel Usage (lb)
Waste Oil	18	19237	163	26.5

2.4.7 Coal Stove

Due to the lack of an EPA method for coal stove operation, the manufacturer's instructions were used to determine fuel loads and operation procedures.

Table 9. Coal Stove Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Stoker Coal	35	High	33.50	220	2.46	25.0
Stoker Coal	23	Low	33.50	294	1.62	22.1
Dried Stoker Coal	20	High	11.20	208	2.64	22.4
Dried Stoker Coal	21	Low	11.20	391	1.50	24.0
Lump Coal	36	Low, Cold Start	25.40	497	2.23	4.0 Birch Kindling, 25.0 Preburn, 25.0 Test
Lump Coal	37	Low	25.40	393	1.38	25.0
Dried Lump Coal	38	Low	19.00	369	1.55	25.0
Stoker Coal	39	Low, Cold Start	33.50	448	2.28	6.0 Birch Kindling, 26.5 Preburn, 25.0 Test

2.4.8 Non-Qualified Outdoor Wood Fired Hydronic Heater

The non-qualified OWHH used for testing required substantially modified procedures in order to generate meaningful results. This unit produced an extreme amount of particulate matter and heat in the flue. Combined with a low dilution factor, this resulted in excessively high particulate concentrations and temperatures in the dilution tunnel – far beyond the capabilities of the sampling systems described in Section 2.3.

All of the sampling systems rely on filters for sample collection or conditioning, and all of the filters would become clogged almost immediately after test start. In addition to the high particulate concentrations, the elevated temperatures produced in the dilution tunnel caused large amounts of water to condense on the cooler filters. Regardless of material, a wet filter will not allow airflow. Solving this problem for the particulate sampling system required a two-pronged approach. The filters were first heated to prevent condensation. The filter holders were placed in a temperature-controlled box featuring a hole for the protuberance of the cyclone head. To solve the particulate problem, a larger bypass filter was used. A 102mm glass bypass filter was employed in place of the 47mm filter, allowing much higher flow through the bypass. The revised filter train is shown in Figure 6. The flow through the sample collection filters was greatly reduced, thus reducing the amount of particulate collected. The air from the bypass filter was cooled using a glass impinger train immersed in an ice bath; silica gel dryers were sufficient for cooling and drying the air from the sample filters.

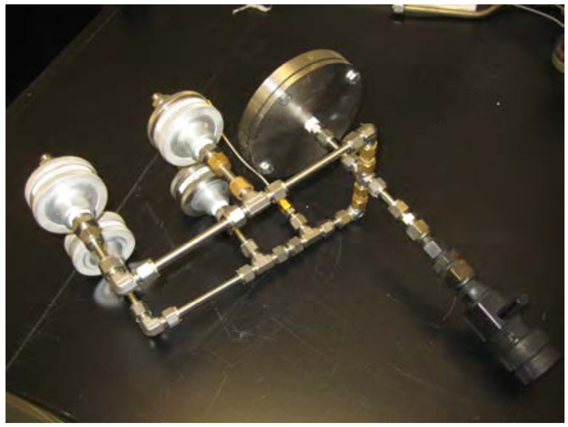


Figure 6. Cyclone and Filter Assembly with 102 mm Glass Filter

Despite this, multiple filter changes were needed for each run. Most frequently changed was the glass bypass filter. Fortunately the effects of these changes were relatively minor, resulting only in a brief (approximately 1 minute) alteration in sample rate.

The gas sampling systems also required adjustment. A dilution system was attempted to reduce flow through the filter while maintaining the required sample rates. However, due to the difficulty in achieving a precise and constant dilution rate throughout each test, it was determined that the most robust technique was not to dilute but to simply closely monitor sample rates and change filters when needed. In some instances gas concentrations exceeded the maximum detection limits of the analyzers. For such cases, data are reported as being greater than the amount measured.

Similar to the EPA qualified OWHH, an additional test was performed on this unit with a retrofit catalyst exhaust stack. This extra test was done burning coal fuel with a low burn setting.

Table 10. Non-Qualified OWHH Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Spruce	25	High	16.91	118	18.57	93.9
Spruce	30	Low	14.00	117	14.12	69.2
Birch	31	High	18.04	115	20.13	100.4
Birch	32	Low	17.02	231	10.09	100.2
Stoker Coal	26	Low	33.50	123	10.89	62.0
Stoker Coal	27	Low, w/ Stack catalyst	33.50	196	6.45	62.0
Birch	33	Low, Cold Start	26.78	346	14.91	40.0 Kindling, 100.2 Preburn, 100.1 Test

2.4.9 Auger-Fed Coal Fired Hydronic Heater

The auger-fed coal burning hydronic heater was tested in accordance to Method 28 WHH for pellet boilers. Two tests were performed with this unit at the same heat output rate, which was approximately 35% of the maximum achievable heat output. The first test was a "cold start", meaning sampling started prior to a fire being lit. A fire was started in the burn pot with newspaper and small kindling wood prior to activating the auger. The second test was identical to the first with regards to burn rate and fuel consumption; however, it was a standard "hot start" per Method 28 WHH.

Table 11. Auger-Fed Coal HH Burn Characteristics

Fuel	Run	Burn Rate (Target)	Fuel Moisture (Avg. %)	Duration (min)	Burn Rate (Dry kg/hr)	Fuel Load (Actual lb)
Wet Stoker Coal	28	Low – Cold Start	33.5	199	15.37	150.0
Wet Stoker Coal	29	Low – Hot Start	33.5	202	15.14	150.0

3. Testing Results

3.1 Particulate Sampling Results

Results from particulate sampling are shown in Appendix A. Speciation was performed on the Teflon filter from each run, generating data for both elemental and ionic emissions. These are reported both as total filter catch and overall gram per hour emissions. For every run, there was no detectable catch for several of the compounds. These are reported as zero. Carbon emissions data were generated from the quartz filter and are broken down into elemental and organic carbon. These data are also reported both as total filter catch and emission rate per hour.

The contracted laboratory encountered difficulties analyzing several of the filters, as their equipment is used to analyze ambient samples, where particle loading is drastically lower. Even with the use of a dilution tunnel, some of the samples were "overloaded", making analysis impossible. The quartz filters, especially, proved difficult to properly analyze. For any instance where and analyte was not measurable, "No Data" is reported in Appendix A.

Total particulate results are summarized in Table 20. Also in Table 20, calculated efficiencies using CSA B415 and EPA M28 WHH (where applicable) are reported and used to compute particulate emissions per useful heat output.

3.2 Ammonia Sampling Results

Results from ammonia sampling are summarized in tables 12 through 19. Analytical lab results of the ammonia samples from each individual run are reported in Appendix B as total ammonia catch as nitrogen. These values were used to calculate the volumetric concentration of ammonia gas in the stack as well as the emission rate of ammonia by weight for each run.

3.3 Gas Sampling Results

Tables 12 through 19 contain air emissions measurements derived from the gas analyzers measuring SO_2, CO, VOCs (as C), NO, NO_2, and NO_x. Tables 12 and 16 compare gas emission rates by appliance type and by fuel type, respectively. Tables 13 and 17 compare gas emission factors (in g/kg of dry fuel) by appliance type and by fuel type, respectively. Tables 14 and 18 compare gas emission factors (in g/MJ input) by appliance type and by fuel type, respectively. Tables 15 and 19 compare gas emission factors (in g/MJ output) by appliance type and by fuel type, respectively. Refer to Appendix C for real time graphs of gas emissions measured during testing. With respect to Appendix C, it should be noted that some units are designed to periodically modulate its burn setting, specifically, the pellet stove and the OWHHs. All appliances with manual air adjustments where left at the same setting for the duration of the test.

Note that for the oil furnace burning fuel oil #1, CO concentration was below the detection limit. Also note that for two of the non-qualified OWHH test runs (runs 25 and 26) the CO analyzer was disconnected from the sampling train. Due to the fact that the filter for the analyzer was constantly plugging, and when it was not plugged the analyzer was far out of its calibration range, it was determined that no useful data could be collected for these runs.

Table 12. Emission Rate of Gas By-Products in g/hr, by Appliance

Run	Appliance	Fuel	Burn Rate	Start	Emission Rate (g/hr)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellet Stove	Pellets	Single	Hot	0.5681	11.09	1.986	5.050	0.1171	4.471	0.08029
3	EPA Wood Stove	Spruce	High	Hot	0.1113	70.36	9.269	2.889	0.7484	3.707	0.1158
6	EPA Wood Stove	Spruce	Low	Hot	0.02587	120.7	14.06	0.6780	0.1197	0.8919	0.1371
2	EPA Wood Stove	Birch	High	Hot	0.2107	108.7	6.613	3.095	1.082	4.556	0.1784
5	EPA Wood Stove	Birch	Low	Hot	0.05873	74.59	23.36	1.249	0.1808	1.544	0.2409
41	EPA Wood Stove	Birch	Low	Cold	0.07125	101.1	26.96	2.299	0.6377	3.368	0.2079
10	EPA OWHH	Spruce	High	Hot	0.002837	334.9	32.80	12.02	0.3301	12.51	0.3869
11	EPA OWHH	Spruce	Low	Hot	0.01611	230.9	77.30	3.320	0.7777	4.612	0.3078
8	EPA OWHH	Birch	High	Hot	0.1965	301.9	104.6	19.80	0.2983	20.23	1.547
9	EPA OWHH	Birch	Low	Hot	0.05227	207.5	75.77	6.042	0.6082	7.069	0.2916
34	EPA OWHH, Catalyst	Birch	Low	Hot	0.1701	63.31	44.29	7.162	0.8584	8.534	0.3163
12	Conventional Wood Stove	Spruce	High	Hot	0.03949	89.52	23.08	4.468	0.7336	5.702	0.2774
14	Conventional Wood Stove	Spruce	Low	Hot	0.04720	359.3	125.8	2.267	0.9782	3.884	0.8025
13	Conventional Wood Stove	Birch	High	Hot	0.2504	470.5	353.1	3.524	3.931	9.989	3.244
15	Conventional Wood Stove	Birch	Low	Hot	0.1100	422.5	313.8	2.130	2.062	5.554	1.821
40	Oil Furnace	Oil #1	Single	Hot	2.361	N/D	2.129	3.808	2.137E-04	3.673	0.01994
17	Oil Furnace	Oil #2	Single	Hot	4.502	0.1259	2.832	2.957	0.1905	3.140	0.006887
18	Waste Oil Burner	Waste Oil	Single	Hot	21.06	7.078	1.989	29.84	0.005961	29.74	0.02072
35	Coal Stove	Wet Stoker Coal	High	Hot	3.835	105.5	17.41	4.847	0.8117	6.197	0.3149
23	Coal Stove	Wet Stoker Coal	Low	Hot	0.3705	107.0	24.89	2.220	0.9022	3.653	1.239
39	Coal Stove	Wet Stoker Coal	Low	Cold	1.706	128.7	33.54	3.537	0.8999	5.038	1.583
20	Coal Stove	Dry Stoker Coal	High	Hot	2.955	82.66	22.49	3.949	0.8896	5.362	0.2209
21	Coal Stove	Dry Stoker Coal	Low	Hot	1.466	98.44	12.99	2.236	0.8425	3.523	0.9764
37	Coal Stove	Wet Lump Coal	Low	Hot	1.212	107.3	11.68	2.597	0.4249	3.292	0.9573
36	Coal Stove	Wet Lump Coal	Low	Cold	0.4983	118.1	42.96	3.147	0.9102	4.663	2.078
38	Coal Stove	Dry Lump Coal	Low	Hot	0.9417	76.59	29.00	2.834	0.5006	3.673	0.6132
25	Non-Qualified OWHH	Spruce	High	Hot	0.9604	N/A	285.2	6.076	3.854	12.38	1.662
30	Non-Qualified OWHH	Spruce	Low	Hot	0.6206	>345.8	>269.3	2.841	1.923	5.991	1.013
31	Non-Qualified OWHH	Birch	High	Hot	0.5069	>392.6	>281.0	8.812	7.582	21.20	4.279
32	Non-Qualified OWHH	Birch	Low	Hot	0.6068	>275.3	>231.3	3.046	4.077	9.761	1.880
33	Non-Qualified OWHH	Birch	Low	Cold	0.3818	314.8	283.4	4.615	5.370	13.45	3.531
26	Non-Qualified OWHH	Wet Stoker Coal	Low	Hot	1.998	N/A	126.4	6.055	4.501	13.39	5.933
27	Non-Qualified OWHH, Catalyst	Wet Stoker Coal	Low	Hot	0.3524	139.1	124.2	5.859	2.963	10.64	5.333
28	Auger-Fed HH	Wet Stoker Coal	Low	Cold	49.91	143.1	2.218	36.82	8.197	50.27	0.2014
29	Auger-Fed HH	Wet Stoker Coal	Low	Hot	50.74	114.7	1.219	35.61	7.804	48.39	0.03969

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 13. Emission Factor of Gas By-Products in g/kg of Dry Fuel, by Appliance

Run	Appliance	Fuel	Burn Rate	Start	Emission Factor (g/kg dry fuel)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellet Stove	Pellets	Single	Hot	0.2543	4.966	0.88910	2.260	0.05244	2.002	0.03594
3	EPA Wood Stove	Spruce	High	Hot	0.02560	16.19	2.133	0.6647	0.1722	0.8531	0.02666
6	EPA Wood Stove	Spruce	Low	Hot	1.462E-02	68.23	7.942	0.3831	0.06766	0.5040	0.07749
2	EPA Wood Stove	Birch	High	Hot	0.05551	28.64	1.742	0.8152	0.2851	1.200	0.04698
5	EPA Wood Stove	Birch	Low	Hot	0.03928	49.89	15.62	0.8356	0.1209	1.033	0.1611
41	EPA Wood Stove	Birch	Low	Cold	0.02272	32.24	8.598	0.7332	0.2034	1.074	0.06632
10	EPA OWHH	Spruce	High	Hot	2.132E-04	25.16	2.464	0.9028	0.02480	0.9400	0.02907
11	EPA OWHH	Spruce	Low	Hot	0.002940	42.14	14.11	0.6058	0.1419	0.8416	0.05617
8	EPA OWHH	Birch	High	Hot	0.01478	22.71	7.868	1.489	0.02244	1.522	0.1164
9	EPA OWHH	Birch	Low	Hot	0.009038	35.87	13.10	1.045	0.1052	1.222	0.06380
34	EPA OWHH, Catalyst	Birch	Low	Hot	0.03415	12.71	8.891	1.438	0.1723	1.713	0.06350
12	Conventional Wood Stove	Spruce	High	Hot	0.002766	6.271	1.617	0.3130	0.05139	0.3995	0.01943
14	Conventional Wood Stove	Spruce	Low	Hot	0.007561	57.58	20.16	0.3634	0.1568	0.6226	0.1286
13	Conventional Wood Stove	Birch	High	Hot	0.02882	54.14	40.63	0.4056	0.4524	1.150	0.3733
15	Conventional Wood Stove	Birch	Low	Hot	0.01514	58.18	43.21	0.2933	0.2839	0.7647	0.2507
40	Oil Furnace	Oil #1	Single	Hot	1.249	N/D	1.126	2.015	1.131E-04	1.943	0.01055
17	Oil Furnace	Oil #2	Single	Hot	2.104	0.05885	1.324	1.382	0.08905	1.468	0.003219
18	Waste Oil Burner	Waste Oil	Single	Hot	4.759	1.600	0.4495	6.745	0.001347	6.721	0.004684
35	Coal Stove	Wet Stoker Coal	High	Hot	1.562	42.96	7.089	1.974	0.3305	2.524	0.1359
23	Coal Stove	Wet Stoker Coal	Low	Hot	0.2366	68.33	15.89	1.418	0.5762	2.333	0.7912
39	Coal Stove	Wet Stoker Coal	Low	Cold	0.7496	56.57	14.74	1.555	0.3955	2.214	0.6960
20	Coal Stove	Dry Stoker Coal	High	Hot	1.153	32.26	8.778	1.541	0.3472	2.093	0.08622
21	Coal Stove	Dry Stoker Coal	Low	Hot	0.9785	65.70	8.666	1.492	0.5623	2.351	0.6516
37	Coal Stove	Wet Lump Coal	Low	Hot	0.8780	77.69	8.459	1.881	0.3078	2.385	0.6934
36	Coal Stove	Wet Lump Coal	Low	Cold	0.2238	53.05	19.29	1.413	0.4087	2.094	0.9331
38	Coal Stove	Dry Lump Coal	Low	Hot	0.6077	49.43	18.72	1.829	0.3231	2.371	0.3957
25	Non-Qualified OWHH	Spruce	High	Hot	0.04020	N/A	11.94	0.2543	0.1613	0.5181	0.06957
30	Non-Qualified OWHH	Spruce	Low	Hot	0.04583	>25.54	>19.89	0.2098	0.1420	0.4424	0.07480
31	Non-Qualified OWHH	Birch	High	Hot	0.02518	>19.50	>13.96	0.4378	0.3767	1.053	0.2126
32	Non-Qualified OWHH	Birch	Low	Hot	0.06015	>27.29	>22.93	0.3019	0.4041	0.9676	0.1863
33	Non-Qualified OWHH	Birch	Low	Cold	0.02561	21.12	19.01	0.3095	0.3602	0.9019	0.2369
26	Non-Qualified OWHH	Wet Stoker Coal	Low	Hot	0.1834	N/A	11.60	0.5559	0.4132	1.229	0.5447
27	Non-Qualified OWHH, Catalyst	Wet Stoker Coal	Low	Hot	0.06218	24.54	21.92	1.034	0.5229	1.878	0.9411
28	Auger-Fed HH	Wet Stoker Coal	Low	Cold	3.248	9.311	0.1444	2.396	0.5334	3.271	0.01311
29	Auger-Fed HH	Wet Stoker Coal	Low	Hot	3.352	7.576	0.08052	2.353	0.5155	3.197	0.002622

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 14. Emission Factor of Gas By-Products in g/MJ Input, by Appliance

Run	Appliance	Fuel	Burn Rate	Start	Emission Factor (g/MJ input)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellet Stove	Pellets	Single	Hot	0.01473	0.2876	0.05150	0.1309	0.003037	0.1159	0.002082
3	EPA Wood Stove	Spruce	High	Hot	0.001590	1.006	0.1325	0.04128	0.01070	0.05298	0.001656
6	EPA Wood Stove	Spruce	Low	Hot	9.078E-04	4.237	0.4932	0.02379	0.004202	0.03130	0.004812
2	EPA Wood Stove	Birch	High	Hot	0.003416	1.762	0.1072	0.05016	0.01755	0.07385	0.002891
5	EPA Wood Stove	Birch	Low	Hot	0.002417	3.070	0.9615	0.05142	0.007441	0.06355	0.009916
41	EPA Wood Stove	Birch	Low	Cold	0.001398	1.984	0.5291	0.04512	0.01252	0.06611	0.004081
10	EPA OWHH	Spruce	High	Hot	1.324E-05	1.562	0.1530	0.05607	0.001540	0.05838	0.001805
11	EPA OWHH	Spruce	Low	Hot	1.826E-04	2.617	0.8760	0.03762	0.008814	0.05227	0.003488
8	EPA OWHH	Birch	High	Hot	9.097E-04	1.397	0.4842	0.09164	0.001381	0.09365	0.007162
9	EPA OWHH	Birch	Low	Hot	5.561E-04	2.207	0.8062	0.06429	0.006472	0.07522	0.003926
34	EPA OWHH, Catalyst	Birch	Low	Hot	0.002102	0.7821	0.5471	0.08848	0.01060	0.1054	0.003907
12	Conventional Wood Stove	Spruce	High	Hot	1.718E-04	0.3895	0.1004	0.01944	0.003192	0.02481	0.001207
14	Conventional Wood Stove	Spruce	Low	Hot	4.696E-04	3.576	1.252	0.02257	0.009737	0.03867	0.007989
13	Conventional Wood Stove	Birch	High	Hot	0.001774	3.332	2.500	0.02496	0.02784	0.07074	0.02297
15	Conventional Wood Stove	Birch	Low	Hot	9.319E-04	3.580	2.659	0.01805	0.01747	0.04705	0.01543
40	Oil Furnace	Oil #1	Single	Hot	0.04707	N/D	0.04244	0.07591	4.261E-06	0.07322	3.974E-04
17	Oil Furnace	Oil #2	Single	Hot	0.08009	0.002240	0.05038	0.05261	0.003389	0.05586	1.225E-04
18	Waste Oil Burner	Waste Oil	Single	Hot	0.1839	0.06181	0.01737	0.2606	5.206E-05	0.2597	1.810E-04
35	Coal Stove	Wet Stoker Coal	High	Hot	0.08134	2.238	0.3693	0.1028	0.01722	0.1314	0.007079
23	Coal Stove	Wet Stoker Coal	Low	Hot	0.01232	3.559	0.8278	0.07384	0.03001	0.1215	0.04121
39	Coal Stove	Wet Stoker Coal	Low	Cold	0.03905	2.946	0.7678	0.08098	0.02060	0.1153	0.03625
20	Coal Stove	Dry Stoker Coal	High	Hot	0.06008	1.680	0.4572	0.08029	0.01809	0.1090	0.004491
21	Coal Stove	Dry Stoker Coal	Low	Hot	0.05097	3.422	0.4514	0.07771	0.02929	0.1225	0.03394
37	Coal Stove	Wet Lump Coal	Low	Hot	0.04735	4.190	0.4562	0.1015	0.01660	0.1286	0.03739
36	Coal Stove	Wet Lump Coal	Low	Cold	0.01207	2.861	1.040	0.07619	0.02204	0.1129	0.05032
38	Coal Stove	Dry Lump Coal	Low	Hot	0.03277	2.665	1.009	0.09863	0.01742	0.1278	0.02134
25	Non-Qualified OWHH	Spruce	High	Hot	0.002497	N/A	0.7413	0.01580	0.01002	0.03218	0.004321
30	Non-Qualified OWHH	Spruce	Low	Hot	0.002846	1.586	1.235	0.01303	0.008820	0.02748	0.004645
31	Non-Qualified OWHH	Birch	High	Hot	0.001550	1.200	0.8590	0.02694	0.02318	0.06480	0.01308
32	Non-Qualified OWHH	Birch	Low	Hot	0.003701	1.679	1.411	0.01858	0.02487	0.05954	0.01146
33	Non-Qualified OWHH	Birch	Low	Cold	0.001576	1.299	1.170	0.01905	0.02216	0.05550	0.01458
26	Non-Qualified OWHH	Wet Stoker Coal	Low	Hot	0.009555	N/A	0.6043	0.02896	0.02152	0.06404	0.02837
27	Non-Qualified OWHH, Catalyst	Wet Stoker Coal	Low	Hot	0.003239	1.278	1.142	0.05385	0.02724	0.09781	0.04902
28	Auger-Fed HH	Wet Stoker Coal	Low	Cold	0.1692	0.4850	0.007519	0.1248	0.02779	0.1704	6.828E-04
29	Auger-Fed HH	Wet Stoker Coal	Low	Hot	0.1746	0.3946	0.004194	0.1225	0.02685	0.1665	1.366E-04

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 15. Emission Factor of Gas By-Products in g/MJ Output, by Appliance

Run	Appliance	Fuel	Burn Rate	Start	Emission Factor (g/MJ output)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellet Stove	Pellets	Single	Hot	0.02043	0.3989	0.07143	0.1816	0.004212	0.1607	0.002888
3	EPA Wood Stove	Spruce	High	Hot	0.002057	1.301	0.1714	0.05340	0.01384	0.06854	0.002142
6	EPA Wood Stove	Spruce	Low	Hot	1.299E-03	6.062	0.7056	0.03403	0.006011	0.04478	0.006884
2	EPA Wood Stove	Birch	High	Hot	0.005053	2.607	0.1586	0.07420	0.02596	0.1092	0.004277
5	EPA Wood Stove	Birch	Low	Hot	0.003433	4.361	1.366	0.07304	0.01057	0.09027	0.01409
41	EPA Wood Stove	Birch	Low	Cold	0.002012	2.854	0.7613	0.06492	0.01801	0.09512	0.005872
10	EPA OWHH	Spruce	High	Hot	1.633E-05	1.926	0.1887	0.06914	0.001899	0.07199	0.002226
11	EPA OWHH	Spruce	Low	Hot	2.597E-04	3.723	1.246	0.05351	0.01254	0.07435	0.004962
8	EPA OWHH	Birch	High	Hot	1.122E-03	1.723	0.5970	0.1130	0.001703	0.1155	0.008831
9	EPA OWHH	Birch	Low	Hot	7.734E-04	3.070	1.121	0.08942	0.009001	0.1046	0.005460
34	EPA OWHH, Catalyst	Birch	Low	Hot	3.204E-03	1.192	0.8340	0.1349	0.01616	0.1607	0.005956
12	Conventional Wood Stove	Spruce	High	Hot	3.416E-04	0.7744	0.1996	0.03865	0.006346	0.04932	0.002400
14	Conventional Wood Stove	Spruce	Low	Hot	7.599E-04	5.786	2.026	0.03652	0.01576	0.06257	0.01293
13	Conventional Wood Stove	Birch	High	Hot	0.003548	6.664	5.000	0.04992	0.05568	0.1415	0.04594
15	Conventional Wood Stove	Birch	Low	Hot	1.561E-03	5.997	4.454	0.03023	0.02926	0.07881	0.02585
40	Oil Furnace	Oil #1	Single	Hot	0.05826	N/D	0.05253	0.09395	5.273E-06	0.09062	4.919E-04
17	Oil Furnace	Oil #2	Single	Hot	0.09489	0.002654	0.05969	0.06233	0.004016	0.06619	1.452E-04
18	Waste Oil Burner	Waste Oil	Single	Hot	0.2620	0.08805	0.02474	0.3713	7.416E-05	0.3700	2.578E-04
35	Coal Stove	Wet Stoker Coal	High	Hot	0.1289	3.547	0.5853	0.1629	0.02729	0.2082	0.01122
23	Coal Stove	Wet Stoker Coal	Low	Hot	0.02047	5.912	1.375	0.1227	0.04985	0.2018	0.06846
39	Coal Stove	Wet Stoker Coal	Low	Cold	0.05298	3.998	1.042	0.1099	0.02795	0.1565	0.04919
20	Coal Stove	Dry Stoker Coal	High	Hot	0.08356	2.337	0.6359	0.1117	0.02516	0.1516	0.006246
21	Coal Stove	Dry Stoker Coal	Low	Hot	0.07507	5.040	0.6648	0.1144	0.04314	0.1804	0.04999
37	Coal Stove	Wet Lump Coal	Low	Hot	0.06504	5.755	0.6266	0.1394	0.02280	0.1767	0.05137
36	Coal Stove	Wet Lump Coal	Low	Cold	0.01631	3.866	1.406	0.1030	0.02978	0.1526	0.06800
38	Coal Stove	Dry Lump Coal	Low	Hot	0.04514	3.671	1.390	0.1358	0.02400	0.1761	0.02939
25	Non-Qualified OWHH	Spruce	High	Hot	0.006258	N/A	1.858	0.03960	0.02511	0.08065	0.01083
30	Non-Qualified OWHH	Spruce	Low	Hot	0.008866	4.941	3.847	0.04059	0.02748	0.08561	0.01447
31	Non-Qualified OWHH	Birch	High	Hot	0.003460	2.679	1.917	0.06013	0.05174	0.1446	0.02920
32	Non-Qualified OWHH	Birch	Low	Hot	0.01111	5.042	4.237	0.05580	0.07468	0.1788	0.03441
33	Non-Qualified OWHH	Birch	Low	Cold	0.004439	3.659	3.296	0.05366	0.06242	0.1563	0.04107
26	Non-Qualified OWHH	Wet Stoker Coal	Low	Hot	0.03196	N/A	2.021	0.09686	0.07197	0.2142	0.09488
27	Non-Qualified OWHH, Catalyst	Wet Stoker Coal	Low	Hot	0.008948	3.530	3.155	0.1488	0.07525	0.2702	0.1354
28	Auger-Fed HH	Wet Stoker Coal	Low	Cold	0.2071	0.5936	0.009203	0.1528	0.03401	0.2086	8.357E-04
29	Auger-Fed HH	Wet Stoker Coal	Low	Hot	0.2219	0.5014	0.005329	0.1557	0.03412	0.2116	1.736E-04

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 16. Emission Rate of Gas By-Products in g/hr, by Fuel Type and Burn Rate

Run	Fuel	Burn Rate	Start	Appliance	Emission Rate (g/hr)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellets	Single	Hot	Pellet Stove	0.5681	11.09	1.986	5.050	0.1171	4.471	0.08029
40	Oil #1	Single	Hot	Oil Furnace	2.361	N/D	2.129	3.808	2.137E-04	3.673	0.01994
17	Oil #2	Single	Hot	Oil Furnace	4.502	0.1259	2.832	2.957	0.1905	3.140	0.006887
18	Waste Oil	Single	Hot	Waste Oil Burner	21.06	7.078	1.989	29.84	0.005961	29.74	0.02072
3	Spruce	High	Hot	EPA Wood Stove	0.1113	70.36	9.269	2.889	0.7484	3.707	0.1158
10	Spruce	High	Hot	EPA OWHH	0.002837	334.9	32.80	12.02	0.3301	12.51	0.3869
12	Spruce	High	Hot	Conventional Wood Stove	0.03949	89.52	23.08	4.468	0.7336	5.702	0.2774
25	Spruce	High	Hot	Non-Qualified OWHH	0.9604	N/A	285.2	6.076	3.854	12.38	1.662
6	Spruce	Low	Hot	EPA Wood Stove	0.02587	120.7	14.06	0.6780	0.1197	0.8919	0.1371
11	Spruce	Low	Hot	EPA OWHH	0.01611	230.9	77.30	3.320	0.7777	4.612	0.3078
14	Spruce	Low	Hot	Conventional Wood Stove	0.04720	359.3	125.8	2.267	0.9782	3.884	0.8025
30	Spruce	Low	Hot	Non-Qualified OWHH	0.6206	>345.8	>269.3	2.841	1.923	5.991	1.013
2	Birch	High	Hot	EPA Wood Stove	0.2107	108.7	6.613	3.095	1.082	4.556	0.1784
8	Birch	High	Hot	EPA OWHH	0.1965	301.9	104.6	19.80	0.2983	20.23	1.547
13	Birch	High	Hot	Conventional Wood Stove	0.2504	470.5	353.1	3.524	3.931	9.989	3.244
31	Birch	High	Hot	Non-Qualified OWHH	0.5069	>392.6	>281.0	8.812	7.582	21.20	4.279
5	Birch	Low	Hot	EPA Wood Stove	0.05873	74.59	23.36	1.249	0.1808	1.544	0.2409
41	Birch	Low	Cold	EPA Wood Stove	0.07125	101.1	26.96	2.299	0.6377	3.368	0.2079
9	Birch	Low	Hot	EPA OWHH	0.05227	207.5	75.77	6.042	0.6082	7.069	0.2916
34	Birch	Low	Hot	EPA OWHH, Catalyst	0.1701	63.31	44.29	7.162	0.8584	8.534	0.3163
15	Birch	Low	Hot	Conventional Wood Stove	0.1100	422.5	313.8	2.130	2.062	5.554	1.821
32	Birch	Low	Hot	Non-Qualified OWHH	0.6068	>275.3	>231.3	3.046	4.077	9.761	1.880
33	Birch	Low	Cold	Non-Qualified OWHH	0.3818	314.8	283.4	4.615	5.370	13.45	3.531
35	Wet Stoker Coal	High	Hot	Coal Stove	3.835	105.5	17.41	4.847	0.8117	6.197	0.3149
23	Wet Stoker Coal	Low	Hot	Coal Stove	0.3705	107.0	24.89	2.220	0.9022	3.653	1.239
39	Wet Stoker Coal	Low	Cold	Coal Stove	1.706	128.7	33.54	3.537	0.8999	5.038	1.583
26	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH	1.998	N/A	126.4	6.055	4.501	13.39	5.933
27	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH, Catalyst	0.3524	139.1	124.2	5.859	2.963	10.64	5.333
28	Wet Stoker Coal	Low	Cold	Auger-Fed HH	49.91	143.1	2.218	36.82	8.197	50.27	0.2014
29	Wet Stoker Coal	Low	Hot	Auger-Fed HH	50.74	114.7	1.219	35.61	7.804	48.39	0.03969
20	Dry Stoker Coal	High	Hot	Coal Stove	2.955	82.66	22.49	3.949	0.8896	5.362	0.2209
21	Dry Stoker Coal	Low	Hot	Coal Stove	1.466	98.44	12.99	2.236	0.8425	3.523	0.9764
37	Wet Lump Coal	Low	Hot	Coal Stove	1.212	107.3	11.68	2.597	0.4249	3.292	0.9573
36	Wet Lump Coal	Low	Cold	Coal Stove	0.4983	118.1	42.96	3.147	0.9102	4.663	2.078
38	Dry Lump Coal	Low	Hot	Coal Stove	0.9417	76.59	29.00	2.834	0.5006	3.673	0.6132

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 17. Emission Factor of Gas By-Products in g/kg of Dry Fuel, by Fuel Type and Burn Rate

Run	Fuel	Burn Rate	Start	Appliance	Emission Factor (g/kg dry fuel)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellets	Single	Hot	Pellet Stove	0.2543	4.966	0.8891	2.260	0.05244	2.002	0.03594
40	Oil #1	Single	Hot	Oil Furnace	1.249	N/D	1.126	2.015	1.131E-04	1.943	0.01055
17	Oil #2	Single	Hot	Oil Furnace	2.104	0.05885	1.324	1.382	0.08905	1.468	0.003219
18	Waste Oil	Single	Hot	Waste Oil Burner	4.759	1.600	0.4495	6.745	0.001347	6.721	0.004684
3	Spruce	High	Hot	EPA Wood Stove	0.02560	16.19	2.133	0.6647	0.1722	0.8531	0.02666
10	Spruce	High	Hot	EPA OWHH	2.132E-04	25.16	2.464	0.9028	0.02480	0.9400	0.02907
12	Spruce	High	Hot	Conventional Wood Stove	0.002766	6.271	1.617	0.3130	0.05139	0.3995	0.01943
25	Spruce	High	Hot	Non-Qualified OWHH	0.04020	N/A	11.94	0.2543	0.1613	0.5181	0.06957
6	Spruce	Low	Hot	EPA Wood Stove	0.01462	68.23	7.942	0.3831	0.06766	0.5040	0.07749
11	Spruce	Low	Hot	EPA OWHH	0.002940	42.14	14.11	0.6058	0.1419	0.8416	0.05617
14	Spruce	Low	Hot	Conventional Wood Stove	0.007561	57.58	20.16	0.3634	0.1568	0.6226	0.1286
30	Spruce	Low	Hot	Non-Qualified OWHH	0.04583	>25.54	>19.89	0.2098	0.1420	0.4424	0.07480
2	Birch	High	Hot	EPA Wood Stove	0.05551	28.64	1.742	0.8152	0.2851	1.200	0.04698
8	Birch	High	Hot	EPA OWHH	0.01478	22.71	7.868	1.489	0.02244	1.522	0.1164
13	Birch	High	Hot	Conventional Wood Stove	0.02882	54.14	40.63	0.4056	0.4524	1.150	0.3733
31	Birch	High	Hot	Non-Qualified OWHH	0.02518	>19.50	>13.96	0.4378	0.3767	1.053	0.2126
5	Birch	Low	Hot	EPA Wood Stove	0.03928	49.89	15.62	0.8356	0.1209	1.033	0.1611
41	Birch	Low	Cold	EPA Wood Stove	0.02272	32.24	8.598	0.7332	0.2034	1.074	0.06632
9	Birch	Low	Hot	EPA OWHH	0.009038	35.87	13.10	1.045	0.1052	1.222	0.06380
34	Birch	Low	Hot	EPA OWHH, Catalyst	0.03415	12.71	8.891	1.438	0.1723	1.713	0.06350
15	Birch	Low	Hot	Conventional Wood Stove	0.01514	58.18	43.21	0.2933	0.2839	0.7647	0.2507
32	Birch	Low	Hot	Non-Qualified OWHH	0.06015	>27.29	>22.93	0.3019	0.4041	0.9676	0.1863
33	Birch	Low	Cold	Non-Qualified OWHH	0.02561	21.12	19.01	0.3095	0.3602	0.9019	0.2369
35	Wet Stoker Coal	High	Hot	Coal Stove	1.562	42.96	7.089	1.974	0.3305	2.524	0.1359
23	Wet Stoker Coal	Low	Hot	Coal Stove	0.2366	68.33	15.89	1.418	0.5762	2.333	0.7912
39	Wet Stoker Coal	Low	Cold	Coal Stove	0.7496	56.57	14.74	1.555	0.3955	2.214	0.6960
26	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH	0.1830	N/A	11.60	0.5559	0.4132	1.229	0.5447
27	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH, Catalyst	0.06218	24.54	21.92	1.034	0.5229	1.878	0.9411
28	Wet Stoker Coal	Low	Cold	Auger-Fed HH	3.248	9.311	0.1444	2.396	0.5334	3.271	0.01311
29	Wet Stoker Coal	Low	Hot	Auger-Fed HH	3.352	7.576	0.08052	2.353	0.5155	3.197	0.002622
20	Dry Stoker Coal	High	Hot	Coal Stove	1.153	32.26	8.778	1.541	0.3472	2.093	0.08622
21	Dry Stoker Coal	Low	Hot	Coal Stove	0.9785	65.70	8.666	1.492	0.5623	2.351	0.6516
37	Wet Lump Coal	Low	Hot	Coal Stove	0.8780	77.69	8.459	1.881	0.3078	2.385	0.6934
36	Wet Lump Coal	Low	Cold	Coal Stove	0.2238	53.05	19.29	1.413	0.4087	2.094	0.9331
38	Dry Lump Coal	Low	Hot	Coal Stove	0.6077	49.43	18.72	1.829	0.3231	2.371	0.3957

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 18. Emission Factor of Gas By-Products in MJ Input, by Fuel Type and Burn Rate

Run	Fuel	Burn Rate	Start	Appliance	Emission Factor (g/MJ input)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellets	Single	Hot	Pellet Stove	0.01473	0.2876	0.05150	0.1309	0.003037	0.1159	0.002082
40	Oil #1	Single	Hot	Oil Furnace	0.04707	N/D	0.04244	0.07591	4.261E-06	0.07322	3.974E-04
17	Oil #2	Single	Hot	Oil Furnace	0.08009	0.002240	0.05038	0.05261	0.003389	0.05586	1.225E-04
18	Waste Oil	Single	Hot	Waste Oil Burner	0.1839	0.06181	0.01737	0.2606	5.206E-05	0.2597	1.810E-04
3	Spruce	High	Hot	EPA Wood Stove	0.001590	1.006	0.1325	0.04128	0.01070	0.05298	0.001656
10	Spruce	High	Hot	EPA OWHH	1.324E-05	1.562	0.1530	0.05607	0.001540	0.05838	0.001805
12	Spruce	High	Hot	Conventional Wood Stove	1.718E-04	0.3895	0.1004	0.01944	0.003192	0.02481	0.001207
25	Spruce	High	Hot	Non-Qualified OWHH	0.002497	N/A	0.7413	0.01580	0.01002	0.03218	0.004321
6	Spruce	Low	Hot	EPA Wood Stove	9.078E-04	4.237	0.4932	0.02379	0.004202	0.03130	0.004812
11	Spruce	Low	Hot	EPA OWHH	1.826E-04	2.617	0.8760	0.03762	0.008814	0.05227	0.003488
14	Spruce	Low	Hot	Conventional Wood Stove	4.696E-04	3.576	1.252	0.02257	0.009737	0.03867	0.007989
30	Spruce	Low	Hot	Non-Qualified OWHH	0.002846	1.586	1.235	0.01303	0.008820	0.02748	0.004645
2	Birch	High	Hot	EPA Wood Stove	0.003416	1.762	0.1072	0.05016	0.01755	0.07385	0.002891
8	Birch	High	Hot	EPA OWHH	9.097E-04	1.397	0.4842	0.09164	0.001381	0.09365	0.007162
13	Birch	High	Hot	Conventional Wood Stove	0.001774	3.332	2.500	0.02496	0.02784	0.07074	0.02297
31	Birch	High	Hot	Non-Qualified OWHH	0.001550	1.200	0.8590	0.02694	0.02318	0.06480	0.01308
5	Birch	Low	Hot	EPA Wood Stove	0.002417	3.070	0.9615	0.05142	0.007441	0.06355	0.009916
41	Birch	Low	Cold	EPA Wood Stove	0.001398	1.984	0.5291	0.04512	0.01252	0.06611	0.004081
9	Birch	Low	Hot	EPA OWHH	5.561E-04	2.207	0.8062	0.06429	0.006472	0.07522	0.003926
34	Birch	Low	Hot	EPA OWHH, Catalyst	0.002102	0.7821	0.5471	0.08848	0.01060	0.1054	0.003907
15	Birch	Low	Hot	Conventional Wood Stove	9.319E-04	3.580	2.659	0.01805	0.01747	0.04705	0.01543
32	Birch	Low	Hot	Non-Qualified OWHH	0.003701	1.679	1.411	0.01858	0.02487	0.05954	0.01146
33	Birch	Low	Cold	Non-Qualified OWHH	0.001600	1.300	1.170	0.01900	0.0222	0.05550	0.01458
35	Wet Stoker Coal	High	Hot	Coal Stove	0.08134	2.238	0.3693	0.1028	0.01722	0.1314	0.007079
23	Wet Stoker Coal	Low	Hot	Coal Stove	0.01232	3.559	0.8278	0.07384	0.03001	0.1215	0.04121
39	Wet Stoker Coal	Low	Cold	Coal Stove	0.03905	2.946	0.7678	0.08098	0.02060	0.1153	0.03625
26	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH	0.009555	N/A	0.6043	0.02896	0.02152	0.06404	0.02837
27	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH, Catalyst	0.003239	1.278	1.142	0.05385	0.02724	0.09781	0.04902
28	Wet Stoker Coal	Low	Cold	Auger-Fed HH	0.1692	0.4850	0.007519	0.1248	0.02779	0.1704	6.828E-04
29	Wet Stoker Coal	Low	Hot	Auger-Fed HH	0.1746	0.3946	0.004194	0.1225	0.02685	0.1665	1.366E-04
20	Dry Stoker Coal	High	Hot	Coal Stove	0.06008	1.680	0.4572	0.08029	0.01809	0.1090	0.004491
21	Dry Stoker Coal	Low	Hot	Coal Stove	0.05097	3.422	0.4514	0.07771	0.02929	0.1225	0.03394
37	Wet Lump Coal	Low	Hot	Coal Stove	0.04735	4.190	0.4562	0.1015	0.01660	0.1286	0.03739
36	Wet Lump Coal	Low	Cold	Coal Stove	0.01207	2.861	1.040	0.07619	0.02204	0.1129	0.05032
38	Dry Lump Coal	Low	Hot	Coal Stove	0.03277	2.665	1.009	0.09863	0.01742	0.1278	0.02134

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 19. Emission Factor of Gas By-Products in MJ Output, by Fuel Type and Burn Rate

Run	Fuel	Burn Rate	Start	Appliance	Emission Factor (g/MJ output)						
					SO_2	CO	VOC (as C)	NO	NO_2	NO_x	NH_3
1	Pellets	Single	Hot	Pellet Stove	0.02043	0.3989	0.07143	0.1816	0.004212	0.1607	0.002888
40	Oil #1	Single	Hot	Oil Furnace	0.05826	N/D	0.05253	0.09395	5.273E-06	0.09062	4.919E-04
17	Oil #2	Single	Hot	Oil Furnace	0.09489	0.002654	0.05969	0.06233	0.004016	0.06619	1.452E-04
18	Waste Oil	Single	Hot	Waste Oil Burner	0.2620	0.08805	0.02474	0.3713	7.416E-05	0.3700	2.578E-04
3	Spruce	High	Hot	EPA Wood Stove	0.002057	1.301	0.1714	0.05340	0.01384	0.06854	0.002142
10	Spruce	High	Hot	EPA OWHH	1.633E-05	1.926	0.1887	0.06914	0.001899	0.07199	0.002226
12	Spruce	High	Hot	Conventional Wood Stove	3.416E-04	0.7744	0.1996	0.03865	0.006346	0.04932	0.002400
25	Spruce	High	Hot	Non-Qualified OWHH	0.006258	N/A	1.858	0.03960	0.02511	0.08065	0.01083
6	Spruce	Low	Hot	EPA Wood Stove	0.001299	6.062	0.7056	0.03403	0.006011	0.04478	0.006884
11	Spruce	Low	Hot	EPA OWHH	2.597E-04	3.723	1.246	0.05351	0.01254	0.07435	0.004962
14	Spruce	Low	Hot	Conventional Wood Stove	7.599E-04	5.786	2.026	0.03652	0.01576	0.06257	0.01293
30	Spruce	Low	Hot	Non-Qualified OWHH	0.008866	4.941	3.847	0.04059	0.02748	0.0856	0.01447
2	Birch	High	Hot	EPA Wood Stove	0.005053	2.607	0.1586	0.07420	0.02596	0.1092	0.004277
8	Birch	High	Hot	EPA OWHH	0.001122	1.723	0.5970	0.1130	0.001703	0.1155	0.008831
13	Birch	High	Hot	Conventional Wood Stove	0.003548	6.664	5.000	0.04992	0.05568	0.1415	0.04594
31	Birch	High	Hot	Non-Qualified OWHH	0.003460	2.679	1.917	0.06013	0.05174	0.1446	0.02920
5	Birch	Low	Hot	EPA Wood Stove	0.003433	4.361	1.366	0.07304	0.01057	0.09027	0.01409
41	Birch	Low	Cold	EPA Wood Stove	0.002012	2.854	0.7613	0.06492	0.01801	0.09512	0.005872
9	Birch	Low	Hot	EPA OWHH	7.734E-04	3.070	1.121	0.08942	0.009001	0.1046	0.005460
34	Birch	Low	Hot	EPA OWHH, Catalyst	0.003204	1.192	0.8340	0.1349	0.01616	0.1607	0.005956
15	Birch	Low	Hot	Conventional Wood Stove	0.001561	5.997	4.454	0.03023	0.02926	0.07881	0.02585
32	Birch	Low	Hot	Non-Qualified OWHH	0.01111	5.042	4.237	0.05580	0.07468	0.1788	0.03441
33	Birch	Low	Cold	Non-Qualified OWHH	0.004507	3.661	3.295	0.05352	0.06254	0.1563	0.04107
35	Wet Stoker Coal	High	Hot	Coal Stove	0.1289	3.547	0.5853	0.1629	0.02729	0.2082	0.01122
23	Wet Stoker Coal	Low	Hot	Coal Stove	0.02047	5.912	1.375	0.1227	0.04985	0.2018	0.06846
39	Wet Stoker Coal	Low	Cold	Coal Stove	0.05298	3.998	1.042	0.1099	0.02795	0.1565	0.04919
26	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH	0.03196	N/A	2.021	0.09686	0.07197	0.2142	0.09488
27	Wet Stoker Coal	Low	Hot	Non-Qualified OWHH, Catalyst	0.008948	3.530	3.155	0.1488	0.07525	0.2702	0.1354
28	Wet Stoker Coal	Low	Cold	Auger-Fed HH	0.2071	0.5936	0.009203	0.1528	0.03401	0.2086	8.357E-04
29	Wet Stoker Coal	Low	Hot	Auger-Fed HH	0.2219	0.5014	0.005329	0.1557	0.03412	0.2116	1.736E-04
20	Dry Stoker Coal	High	Hot	Coal Stove	0.08356	2.337	0.6359	0.1117	0.02516	0.1516	0.006246
21	Dry Stoker Coal	Low	Hot	Coal Stove	0.07507	5.040	0.6648	0.1144	0.04314	0.1804	0.04999
37	Wet Lump Coal	Low	Hot	Coal Stove	0.06504	5.755	0.6266	0.1394	0.02280	0.1767	0.05137
36	Wet Lump Coal	Low	Cold	Coal Stove	0.01631	3.866	1.406	0.1030	0.02978	0.1526	0.06800
38	Dry Lump Coal	Low	Hot	Coal Stove	0.04514	3.671	1.390	0.1358	0.02400	0.1761	0.02939

N/D = Below detection limit
N/A = No data available
>[value] = Exceeded instrument limit

Table 20. Particulate Emissions and Efficiency, by Run

Run	Appliance	Fuel	Burn Rate	PM2.5 Emissions (g/hr)	PM2.5 Emissions Factor (g/kg)	Lower Heating Value Efficiency* (%)	Emissions (g/MJ input)	Emissions (g/MJ output)
1	Pellet Stove	Alaskan Pellets	Single	3.31	1.48	72.1	0.080	0.111
2	EPA Certified Woodstove	Birch	High	2.00	0.53	67.6	0.030	0.045
3	EPA Certified Woodstove	Spruce	High	1.27	0.30	77.3	0.017	0.022
5	EPA Certified Woodstove	Birch	Low	6.17	4.11	70.4	0.235	0.334
6	EPA Certified Woodstove	Spruce	Low	1.68	0.95	69.9	0.055	0.079
8	EPA Qualified OWHH	Birch	High	10.72	0.81	81.1**	0.046	0.057
9	EPA Qualified OWHH	Birch	Low	14.07	2.66	71.9**	0.152	0.212
10	EPA Qualified OWHH	Spruce	High	5.12	0.38	81.1**	0.022	0.027
11	EPA Qualified OWHH	Spruce	Low	4.32	0.79	70.3**	0.046	0.065
12	Conventional Woodstove	Spruce	High	2.89	0.45	50.3	0.026	0.051
13	Conventional Woodstove	Birch	High	94.56	10.89	50	0.623	1.246
14	Conventional Woodstove	Spruce	Low	14.89	2.39	61.8	0.138	0.223
15	Conventional Woodstove	Birch	Low	44.92	6.19	59.7	0.354	0.593
17	Central Heating Indoor Furnace	No. 2 Heating Oil	Single	0.25	0.12	78.5	0.003	0.003
18	Waste Oil Burner	Waste Motor Oil	Single	10.41	0.67	66.2	0.015	0.023
20	Coal Stove	Dry Stoker Coal	High	17.45	6.61	71.9	0.330	0.459
21	Coal Stove	Dry Stoker Coal	Low	1.74	1.16	67.9	0.058	0.085
23	Coal Stove	Stoker Coal	Low	11.13	7.09	60.2	0.354	0.589
25	Non Qualified OWHH	Spruce	High	130.10	7.01	51.5**	0.405	0.787
26	Non Qualified OWHH	Coal	Low	294.60	27.05	29.9**	1.352	4.522
27	Non Qualified OWHH	Coal w/ ClearStak	Low	135.60	23.92	36.2**	1.195	3.302
28	Auger-fed HH	Coal (cold start)	Low	7.28	0.45	81.7	0.023	0.028
29	Auger-fed HH	Coal (hot start)	Low	7.71	0.47	78.7	0.024	0.030
30	Non Qualified OWHH	Spruce	Low	166.60	12.30	33.1**	0.711	2.150
31	Non Qualified OWHH	Birch	High	119.30	5.93	44.8**	0.339	0.757
32	Non Qualified OWHH	Birch	Low	44.47	4.41	33.3**	0.252	0.757
33	Non Qualified OWHH	Birch (cold start)	Low	34.75	2.33	35.5**	0.133	0.376
34	EPA Qualified OWHH	Birch w/ ClearStak	Low	33.82	6.79	65.6**	0.389	0.592
35	Coal Stove	Stoker Coal	High	7.83	3.18	63.1	0.159	0.252
36	Coal Stove	Lump Coal (cold start)	Low	16.32	6.48	74	0.335	0.453
37	Coal Stove	Lump Coal	Low	2.75	1.99	72.8	0.103	0.142
38	Coal Stove	Dry Lump Coal	Low	8.19	5.28	72.6	0.274	0.377
39	Coal Stove	Stoker Coal (cold start)	Low	14.49	6.36	73.7	0.318	0.431
40	Central Heating Indoor Furnace	No. 1 Heating Oil	Single	0.31	0.16	80.2	0.004	0.004
41	EPA Certified Woodstove	Birch (cold start)	Low	6.86	2.18	69.5	0.125	0.180

*Efficiencies calculated using CSAB415.1-10 Stack Loss Method unless otherwise noted
**Efficiencies calculated per EPA Method 28 WHH, based on delivered heat output to the load side of the heat exchanger

4. Summary

4.1 Scope and Methods

A wide variety of source testing measurements were taken on a selection of home heating appliances. Emissions from nine appliances, each representative of a popular category, were sampled while burning fuel local to the Fairbanks North Star Borough area. Wood-burning appliances included a conventional wood stove, an EPA certified wood stove, and one each of EPA Phase-II qualified and non-qualified outdoor wood-fired hydronic heaters. The wood used for these tests was birch and spruce cordwood of typical moisture. A coal stove utilized local coal, both typical moisture and air-dried. A pellet stove used local wood pellets. Heating oil (both #1 and #2) was burned in an oil heater. Finally, used motor oil from local sources was used to fuel a waste oil burner.

Sampling was conducted using four separate systems, three of which sampled out of a dilution tunnel. The first was a gas sampling system which measured volatile organic compounds, SO_2, CO, NO, and NO_x. Combustion gas (O_2, CO_2, and CO) gas measurements were taken directly from the stack. The third system sampled ammonia as nitrogen by pulling the sample though sulfuric acid which was then recovered and analyzed for nitrogen. Finally, particulate matter was sampled using a single cyclone head to deliver particulate matter under 2.5 microns in diameter to four sample filters. All of the sampling performed was governed by applicable EPA methods.

4.2 Summary of Results

4.2.1 Comparison of Emissions per Useful Heat Output

In an effort to compare the performance of a wide variety of appliances, the following figures were created to provide some illustrations of the particulate matter emissions based on the amount of useful heat created.

Figure 7 shows the various single room heating, wood-burning appliances tested. The data shows that EPA certified stoves burn cleaner than the older, conventional stoves. Additionally, it appears that for these appliances spruce generally burns cleaner than birch.

Figure 7. Particulate Emissions per Useful Heat Output, Wood Burning Space Heaters

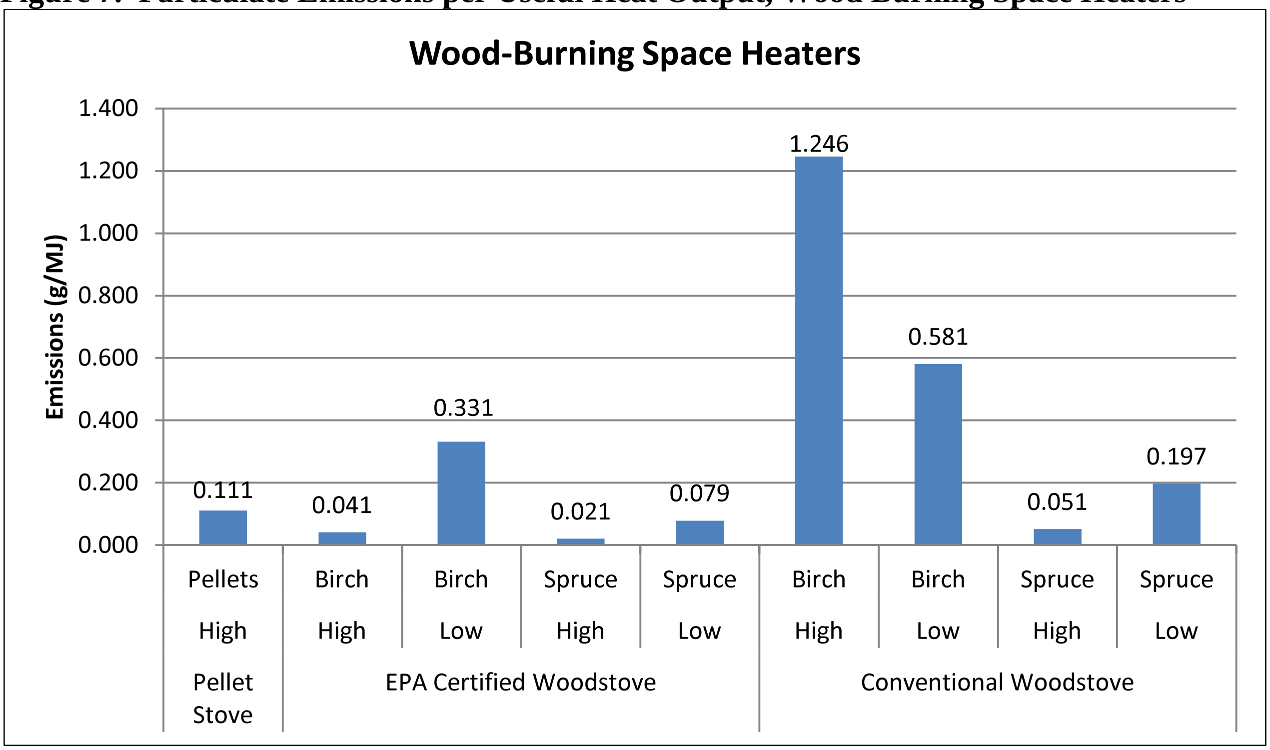


Figure 8 is a comparison of outdoor hydronic heaters, burning both wood and coal. Again, the EPA qualified model is significantly cleaner than the non-qualified unit, which produced extremely high emissions while burning coal. Due to difficulties encountered during testing (See section 2.4.8), the uncertainty of the results for that appliance is much higher than that of other appliances. However, OMNI is confident that the very high emissions of the unit are accurately reflected by the data, and therefore the data is still useful for comparative purposes. The auger-fed HH shows that coal can be burned in a clean manner. With regards to the wood burning devices, there does not appear to be a significant difference between birch and spruce.

Figure 8. Particulate Emissions per Useful Heat Output, Outdoor Hydronic Heaters

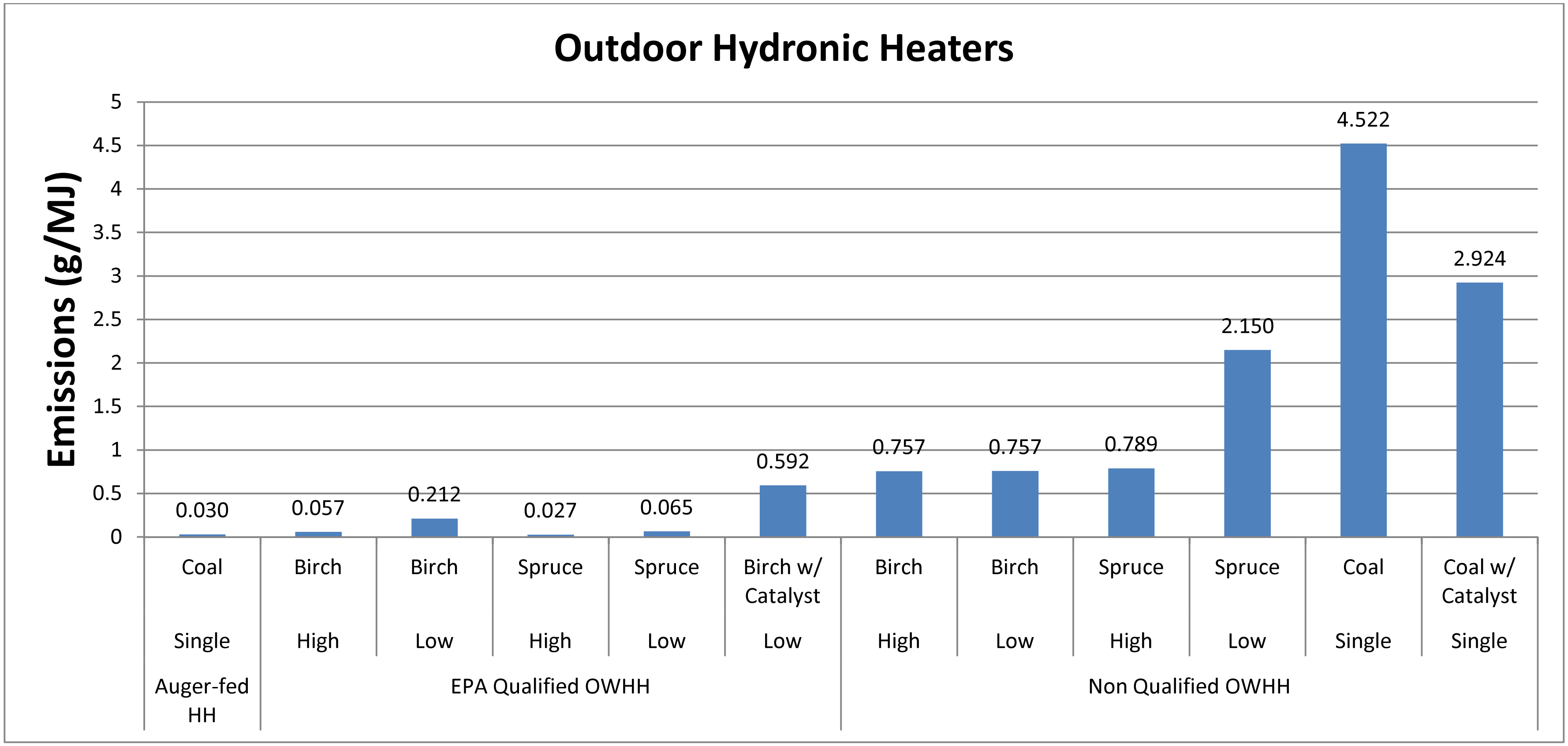


Figure 9 shows the results of the coal-fired room heater. There does not appear to be any particular pattern or favorable fuel based on the available data. Comparing it the wood-burning room heaters, the performance is similar to that of the conventional wood stove.

Figure 9. Particulate Emissions per Useful Heat Output, Coal Heater

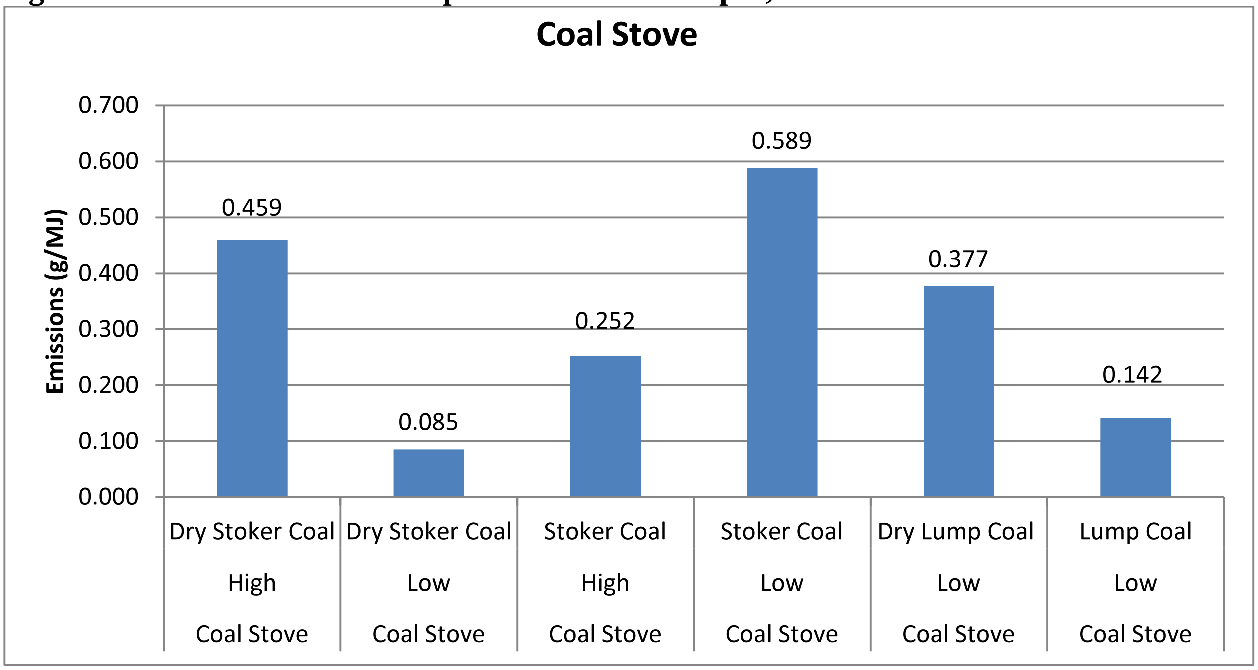
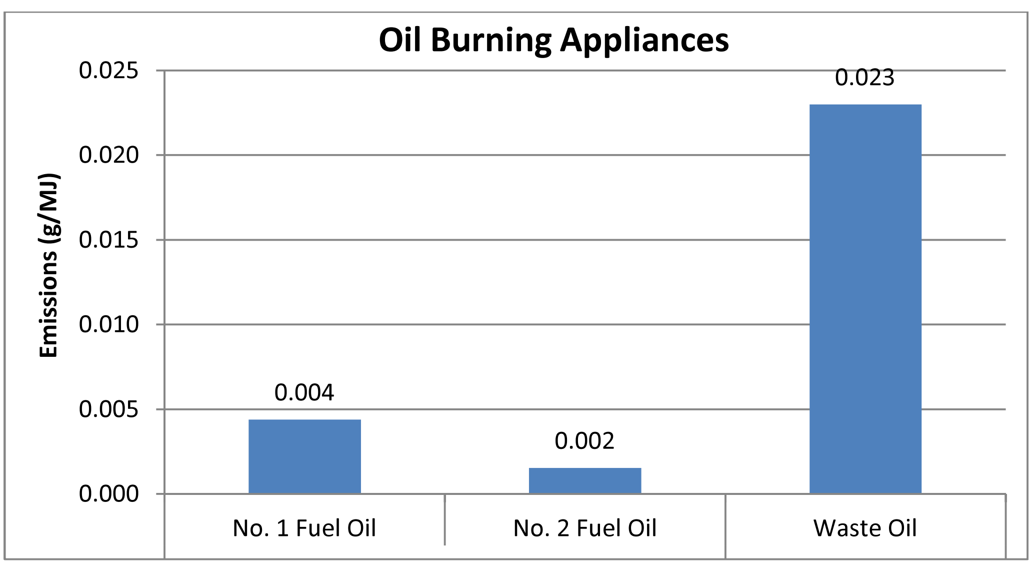


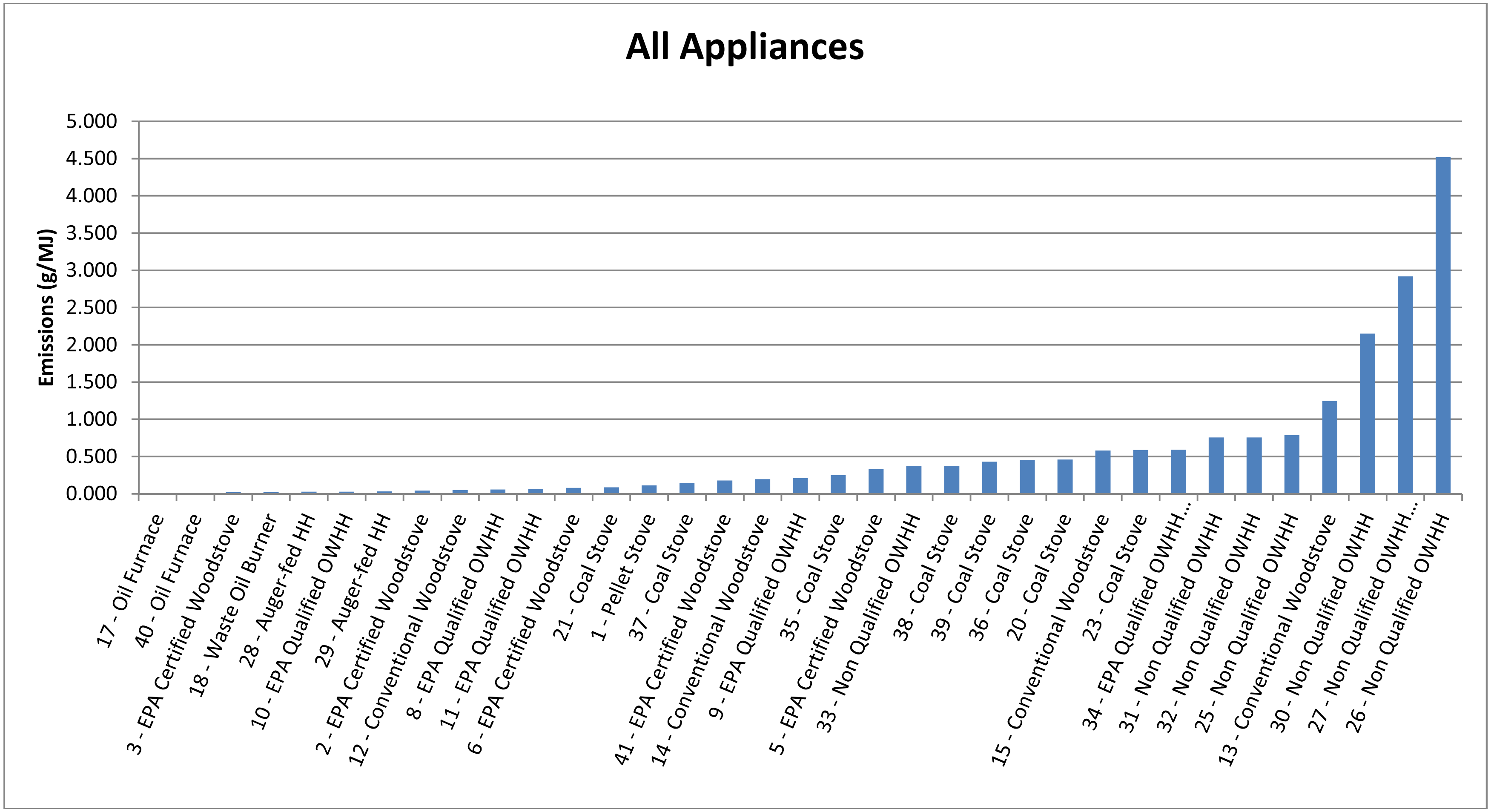
Figure 10 shows that all oil fuels produce low amounts of particulate matter. The makeup of the emissions from the waste oil burner is of particular note, however, due to additional compounds found in the fuel. Increased levels of chlorine, phosphorous, potassium and zinc were observed for this run. See Appendix A for a full analysis.

Figure 10. Particulate Emissions per Useful Heat Output, Oil-Burning Furnaces



Finally, Figure 11 shows a comparison of all appliances tested. With the exception of some overlap, there is a clear delineation between cleaner burning appliances and high emissions appliances. The models that are EPA certified or qualified are, in general, more efficient and cleaner burning. Additionally, all of the continuously fed units - the auger-fed HH, and the oil units - are designed for optimal burning conditions and efficiency, which is reflected in the data.

Figure 11. Particulate Emissions per Useful Heat Output, All Appliances



4.2.2 Cold Start Comparison

The emissions of a cold start test can be modeled as emissions from each phase (fuel load) of the test, that is, the kindling phase, the preburn phase, and the test fuel phase. Emissions (in terms of total particulate) from each phase are added together to generate total emissions for the run:

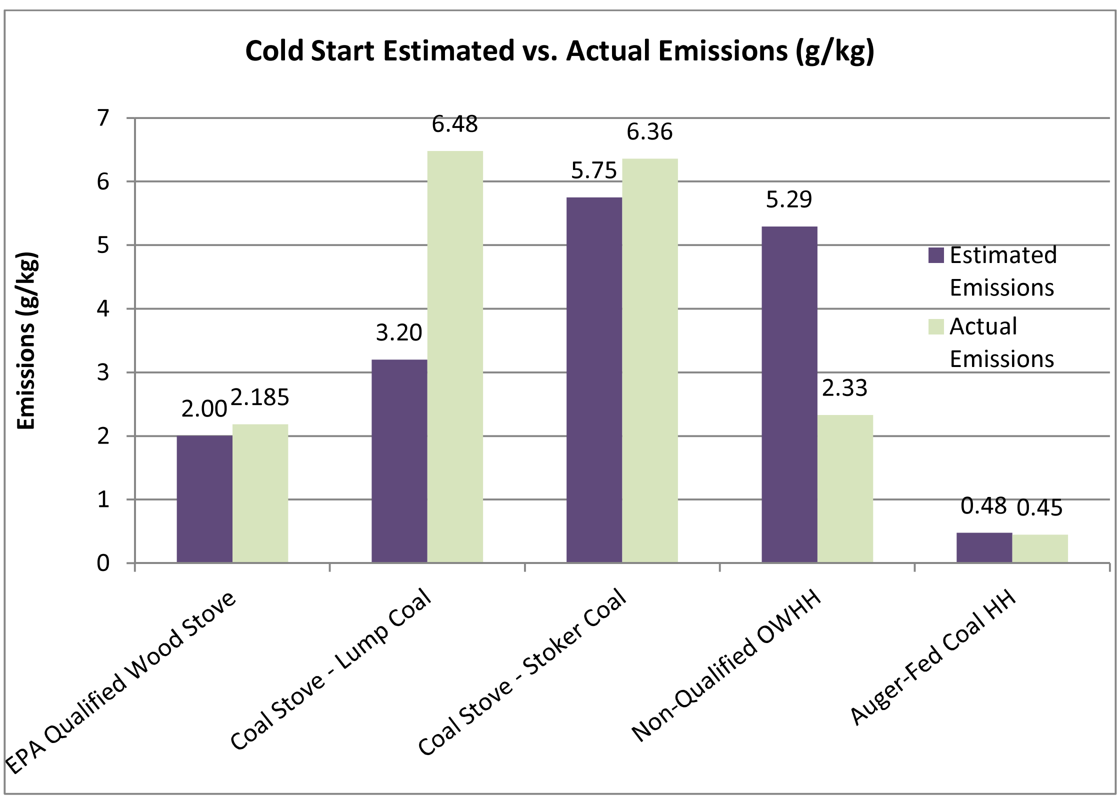
$$E_{Cold\ Start} = E_{Kindling} + E_{Preburn} + E_{Test\ Fuel}$$

Similarly, emissions factors (in grams per kilogram) can be added together to generate an estimated overall emissions factor for the run. These emissions factors come from tests performed earlier in the study. An example governing equation (for a birch low burn cold start) is shown below:

$$EF_{Cold\ Start} = \frac{EF_{Birch\ High}(m_{Kindling}) + EF_{Birch\ High}(m_{Preburn}) + EF_{Birch\ Low}(m_{Test\ Fuel})}{m_{Total}}$$

Using this method, expected emission rates were calculated for each cold start test. These data points were then compared to the actual emission rates for these runs, the difference between the estimated and actual values are presumably the effect of higher emissions from the cold start. Results are shown in Figure 12. The results for the Non-Qualified OWHH seem to be anomalous and are most likely the effect of high variability in a high emissions unit burning large quantities of fuel.

Figure 12. Comparison of Expected and Actual Cold Start Emissions



4.2.3 AP-42 Data Comparison

The issue has been raised that data generated by OMNI for this report are, in some cases, inconsistent with data from AP-42, *Compilation of Air Pollutant Emission Factors*. See Figure 13 for PM2.5 comparison data. This section of the report has been prepared to address the potential reasons for the discrepancy.

Table 21. PM2.5 Comparison of OMNI and AP42 Data

	PM 2.5 (lb/ton)	
	OMNI	**AP42 [1]**
Conventional Wood Stove	0.9-21.8	30.6
EPA-certified Wood Stove	0.6-8.2	14.6-20.0
Non-qualified OWHH	4.7-54.1	27.0*
EPA-qualified OWHH	0.8-5.3	4.3-8.1*
Pellet Stove	3.0	4.2-8.8
Oil Furnace	0.2-0.3	0.1*
Waste Oil	1.3	7.4*
Coal Stove	2.3-14.2	6.2

*Alaska emission inventory estimates (based on AP-42 or other sources, with assumed fuel properties)

While the coal stove and oil furnace data is similar in both the OMNI and AP-42 studies, for all other appliances the OMNI emissions rates are noticeably lower. The causes of this can be found in differences between the data collection procedures.

A primary goal of OMNI's testing was a high degree of consistency between runs due to small sample size. This was achieved by the use of EPA Method 28, which governs testing procedures for wood-fired appliances. Method 28 was written to assure consistent, comparable results across different appliances, making it ideal for this testing.

AP-42 is intended as a compendium of emissions data. The data collection procedure for wood stove emissions is described as follows in this excerpt from the 5th edition of the report, "The emission factors for PM and CO in Tables 1.10-1 and 1.10-2 are averages, derived entirely from field test data obtained under actual operating conditions." [2] The realism of the reported averages was achieved by virtue of the wide array of differences between the studies, and variability within those studies, which together create a large amalgam of field-use situations.

The data show that Method 28 results are moderately lower than field results. This is strongly supported by data from a field use study very similar to those cited by AP-42, *Long-Term Performance of EPA-Certified Phase 2 Woodstoves, Klamath Falls and Portland, Oregon: 1998/1999*. This study generated field emissions rate values for several stoves already certified by the EPA. A comparison between the emissions rates generated from certification testing and those from field testing is shown in Figure 14.

Table 22. Method 28 vs. Field Data

Appliance Name	Emissions Rate (Method 28 Certification) [g/hr] [3]	Emissions Rate (field) [g/hr][4]
Hearth and Home Quadrafire 2100	2.0	8.9
Pacific Energy Super 27	3.4	5.2
Waterford Stanley Limited 104 MK II	2.9	4.0
Country Stoves T-Top	5.7	9.9

This data shows that Method 28 results tend to have lower emissions rates than actual field testing. The differences in emission rates between OMNI and AP-42 data are primarily due to this discrepancy.

References

1. AP- 42 *Compilation of Air Pollutant Emission Factors*, United States Environmental Protection Agency, October 1996.

2. ibid.

3. *List of EPA Certified Wood Stoves*, United States Environmental Protection Agency, September 2011

4. L . H. Fisher, J. E. Houck, P. E. Tiegs, J. McGaughey, In *Long-Term Performance of EPA-Certified Phase 2 Woodstoves, Klamath Falls and Portland, Oregon: 1998/1999*, OMNI Environmental Services, Inc., Beaverton, OR, 1999.

Measurement of Space-Heating Emissions

Appendix A

$PM_{2.5}$ Laboratory Results

Appliance:	Pellet Stove	**Burn Rate:**	High	**Run #:**	1
Fuel:	Alaskan Pellets	**Date:**	3/8/2011		

Filter Information:

T1 ID #:	A7518110
T1 Flow Rate [mL/min]:	4887
T1 Sample Volume [dsft^3]:	*20.67*
Q1 ID #:	A7518410
Q1 Flow Rate [mL/min]:	1026
Q1 Sample Volume [dsft^3]:	*4.34*

Run Information:

Test Duration [min]:	120
Tunnel Flow [dsft^3/min]:	470.8448
Barometric Pressure [in Hg]:	30.12
Temperature [°F]	73
Avg Delta H [in H2O]:	0.45

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**2422.00**	**3.311E+00**
K^+	876.88	1.199E+00
Na^+	7.53	1.030E-02
NH_4^+	0.00	0.000E+00
NO_3	25.38	3.469E-02
SO_4	299.55	4.095E-01
Silver	0.09	1.237E-04
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.07	9.242E-05
Bromine	0.14	1.893E-04
Calcium	2.13	2.912E-03
Cadmium	0.00	0.000E+00
Cerium	0.06	8.195E-05
Chlorine	36.28	4.960E-02
Cobalt	0.11	1.531E-04
Chromium	0.17	2.377E-04
Cesium	0.00	0.000E+00
Copper	0.69	9.416E-04
Iron	0.40	5.460E-04
Indium	0.00	0.000E+00
Potassium	922.77	1.261E+00
Magnesium	0.81	1.108E-03
Manganese	1.07	1.465E-03
Sodium	30.97	4.233E-02
Nickel	0.04	5.612E-05
Phosphorous	0.00	0.000E+00
Lead	0.16	2.126E-04
Rubidium	1.64	2.246E-03
Sulfur	106.04	1.449E-01
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.02	2.634E-05
Titanium	0.02	3.250E-05
Vanadium	0.00	0.000E+00
Zinc	39.89	5.453E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	48.39	3.151E-01
Organic Carbon	59.09	3.847E-01

Appliance:	EPA Wood Stove	Burn Rate:	High	Run #:	2
Fuel:	Birch	Date:	3/9/2011		

Filter Information:

T1 ID #:	A751810N
T1 Flow Rate [mL/min]:	5697
T1 Sample Volume [dsft^3]:	*20.14*
Q1 ID #:	A751856I
Q1 Flow Rate [mL/min]:	1039
Q1 Sample Volume [dsft^3]:	*3.67*

Run Information:

Test Duration [min]:	101
Tunnel Flow [dsft^3/min]:	459.4511
Barometric Pressure [in Hg]:	30.09
Temperature [°F]	76
Avg Delta H [in H2O]:	0.44

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**1461.00**	**1.999E+00**
K^+	73.04	9.995E-02
Na^+	0.67	9.235E-04
NH_4^+	0.23	3.206E-04
NO_3	15.71	2.150E-02
SO_4	46.62	6.380E-02
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.06	8.127E-05
Bromine	0.25	3.453E-04
Calcium	1.64	2.249E-03
Cadmium	0.01	1.547E-05
Cerium	0.00	0.000E+00
Chlorine	38.85	5.317E-02
Cobalt	0.05	7.001E-05
Chromium	0.08	1.065E-04
Cesium	0.00	0.000E+00
Copper	0.02	3.101E-05
Iron	0.41	5.546E-04
Indium	0.05	6.187E-05
Potassium	84.55	1.157E-01
Magnesium	1.43	1.959E-03
Manganese	0.21	2.908E-04
Sodium	29.74	4.071E-02
Nickel	0.04	4.871E-05
Phosphorous	0.00	0.000E+00
Lead	0.10	1.394E-04
Rubidium	0.14	1.919E-04
Sulfur	17.99	2.462E-02
Antimony	0.00	0.000E+00
Selenium	0.04	5.110E-05
Silicon	3.03	4.144E-03
Tin	0.00	0.000E+00
Strontium	0.00	4.644E-06
Titanium	0.03	4.222E-05
Vanadium	0.00	0.000E+00
Zinc	37.16	5.085E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	155.30	1.165E+00
Organic Carbon	73.97	5.551E-01

Appliance:	EPA Wood Stove	**Burn Rate:**	High	**Run #:**	3
Fuel:	Spruce	**Date:**	3/10/2011		

Filter Information:

T1 ID #:	A751809U
T1 Flow Rate [mL/min]:	5445
T1 Sample Volume [$dsft^3$]:	*15.86*
Q1 ID #:	A7518550
Q1 Flow Rate [mL/min]:	1043
Q1 Sample Volume [$dsft^3$]:	*3.04*

Run Information:

Test Duration [min]:	83
Tunnel Flow [$dsft^3$/min]:	461.2901
Barometric Pressure [in Hg]:	29.93
Temperature [°F]	72
Avg Delta H [in H2O]:	0.45

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**728.00**	**1.271E+00**
K^+	62.52	1.091E-01
Na^+	0.77	1.340E-03
NH_4^+	0.01	2.552E-05
NO_3	14.41	2.516E-02
SO_4	41.13	7.179E-02
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.02	3.751E-05
Barium	0.02	3.574E-05
Bromine	0.09	1.540E-04
Calcium	1.27	2.221E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	18.44	3.219E-02
Cobalt	0.01	2.610E-05
Chromium	0.04	7.587E-05
Cesium	0.00	0.000E+00
Copper	0.06	1.126E-04
Iron	0.14	2.512E-04
Indium	0.00	0.000E+00
Potassium	72.61	1.267E-01
Magnesium	0.63	1.102E-03
Manganese	0.10	1.669E-04
Sodium	11.53	2.013E-02
Nickel	0.10	1.769E-04
Phosphorous	0.00	0.000E+00
Lead	0.03	4.540E-05
Rubidium	0.07	1.184E-04
Sulfur	16.56	2.890E-02
Antimony	0.00	0.000E+00
Selenium	0.00	3.949E-06
Silicon	1.24	2.161E-03
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.00	1.986E-06
Vanadium	0.00	0.000E+00
Zinc	15.21	2.655E-02
Zirconium	0.01	9.864E-06

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon	31.19	2.842E-01
Organic Carbon	71.00	6.469E-01

Appliance:	EPA Wood Stove	Burn Rate:	Low	Run #:	5
Fuel:	Birch	Date:	3/17/2011		

Filter Information:

T1 ID #:	A751977 & A751801M
T1 Flow Rate [mL/min]:	2555
T1 Sample Volume [dsft^3]:	*22.45*
Q1 ID #:	A751853Y
Q1 Flow Rate [mL/min]:	1073
Q1 Sample Volume [dsft^3]:	*9.43*

Run Information:

Test Duration [min]:	248
Tunnel Flow [dsft^3/min]:	464.6459
Barometric Pressure [in Hg]:	30.11
Temperature [°F]	70
Avg Delta H [in H2O]:	0.44

Teflon Sample:	Catch [μg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**4965.00**	**6.166E+00**
K^+	78.20	9.712E-02
Na^+	1.09	1.351E-03
NH_4^+	0.52	6.498E-04
NO_3	4.81	5.979E-03
SO_4	37.08	4.605E-02
Silver	0.00	0.000E+00
Aluminum	0.40	4.982E-04
Arsenic	0.00	0.000E+00
Barium	0.12	1.512E-04
Bromine	0.09	1.067E-04
Calcium	1.17	1.458E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	11.12	1.381E-02
Cobalt	0.03	3.350E-05
Chromium	0.13	1.565E-04
Cesium	0.07	8.628E-05
Copper	0.08	9.561E-05
Iron	0.61	7.536E-04
Indium	0.23	2.807E-04
Potassium	89.53	1.112E-01
Magnesium	0.64	7.975E-04
Manganese	0.17	2.160E-04
Sodium	9.15	1.137E-02
Nickel	0.05	6.823E-05
Phosphorous	0.00	0.000E+00
Lead	0.01	1.123E-05
Rubidium	0.15	1.910E-04
Sulfur	20.43	2.537E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.08	9.825E-05
Strontium	0.03	3.370E-05
Titanium	0.00	0.000E+00
Vanadium	0.04	4.382E-05
Zinc	18.32	2.275E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [μg]:	Emission Rate [g/hr]
Elemental Carbon	396.68	1.173E+00
Organic Carbon	4408.43	1.304E+01

Appliance:	EPA Wood Stove	Burn Rate:	Low	Run #:	6
Fuel:	Spruce	Date:	3/18/2011		

Filter Information:

T1 ID #:	A751807S
T1 Flow Rate [mL/min]:	815
T1 Sample Volume [dsft^3]:	5.98
Q1 ID #:	A751842V
Q1 Flow Rate [mL/min]:	960
Q1 Sample Volume [dsft^3]:	7.05

Run Information:

Test Duration [min]:	210
Tunnel Flow [dsft^3/min]:	477.7275
Barometric Pressure [in Hg]:	29.94
Temperature [°F]	74
Avg Delta H [in H2O]:	0.42

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**351.00**	**1.681E+00**
K^+	2.60	1.247E-02
Na^+	0.21	1.021E-03
NH_4^+	0.06	2.808E-04
NO_3	1.49	7.149E-03
SO_4	1.73	8.295E-03
Silver	0.00	0.000E+00
Aluminum	0.10	4.904E-04
Arsenic	0.00	0.000E+00
Barium	0.01	4.878E-05
Bromine	0.01	5.251E-05
Calcium	0.41	1.982E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.82	3.912E-03
Cobalt	0.00	1.733E-05
Chromium	0.01	4.279E-05
Cesium	0.01	2.710E-05
Copper	0.00	0.000E+00
Iron	0.03	1.327E-04
Indium	0.00	0.000E+00
Potassium	2.84	1.359E-02
Magnesium	0.00	0.000E+00
Manganese	0.02	1.078E-04
Sodium	0.00	0.000E+00
Nickel	0.06	2.724E-04
Phosphorous	0.00	0.000E+00
Lead	0.01	3.789E-05
Rubidium	0.00	0.000E+00
Sulfur	0.84	4.047E-03
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.01	6.496E-05
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	0.29	1.397E-03
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	41.62	1.693E-01
Organic Carbon	321.87	1.309E+00

Appliance:	EPA OWHH	Burn Rate:	High	Run #:	8
Fuel:	Birch	Date:	3/22/2011		

Filter Information:

T1 ID #:	A751804P
T1 Flow Rate [mL/min]:	923.86
T1 Sample Volume [$dsft^3$]:	7.98
Q1 ID #:	A7518521X
Q1 Flow Rate [mL/min]:	1068.9
Q1 Sample Volume [$dsft^3$]:	9.23

Run Information:

Test Duration [min]:	243
Tunnel Flow [$dsft^3$/min]:	468.0051
Barometric Pressure [in Hg]:	30.1
Temperature [°F]	68
Avg Delta H [in H2O]:	0.45

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**3048.00**	**1.072E+01**
K^+	360.13	1.267E+00
Na^+	3.58	1.260E-02
NH_4^+	1.11	3.919E-03
NO_3	10.06	3.540E-02
SO_4	204.77	7.204E-01
Silver	0.07	2.387E-04
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.39	1.385E-03
Bromine	0.38	1.340E-03
Calcium	7.96	2.802E-02
Cadmium	0.25	8.752E-04
Cerium	0.00	0.000E+00
Chlorine	46.79	1.646E-01
Cobalt	0.07	2.575E-04
Chromium	0.10	3.373E-04
Cesium	0.00	0.000E+00
Copper	0.18	6.375E-04
Iron	0.31	1.081E-03
Indium	0.00	0.000E+00
Potassium	451.88	1.590E+00
Magnesium	4.07	1.433E-02
Manganese	1.02	3.573E-03
Sodium	32.70	1.150E-01
Nickel	0.02	8.393E-05
Phosphorous	0.35	1.226E-03
Lead	0.34	1.201E-03
Rubidium	0.80	2.798E-03
Sulfur	107.14	3.769E-01
Antimony	0.00	0.000E+00
Selenium	0.03	1.197E-04
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.07	2.550E-04
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	60.01	2.111E-01
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	297.08	9.034E-01
Organic Carbon	1688.39	5.134E+00

Appliance:	EPA OWHH	Burn Rate:	Low	Run #:	9
Fuel:	Birch	Date:	3/22/2011		

Filter Information:

T1 ID #:	A7518030
T1 Flow Rate [mL/min]:	780.85
T1 Sample Volume [dsft^3]:	*17.25*
Q1 ID #:	A751851W
Q1 Flow Rate [mL/min]:	875.09
Q1 Sample Volume [dsft^3]:	*19.33*

Run Information:

Test Duration [min]:	620
Tunnel Flow [dsft^3/min]:	494.703
Barometric Pressure [in Hg]:	30.05
Temperature [℉]	66
Avg Delta H [in H2O]:	0.44

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**8178.00**	**1.407E+01**
K^+	186.23	3.205E-01
Na^+	1.98	3.409E-03
NH_4^+	1.08	1.863E-03
NO_3	10.05	1.729E-02
SO_4	78.32	1.348E-01
Silver	0.02	3.890E-05
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.08	1.381E-04
Bromine	0.16	2.823E-04
Calcium	4.72	8.114E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	31.88	5.486E-02
Cobalt	0.04	6.895E-05
Chromium	0.09	1.463E-04
Cesium	0.00	0.000E+00
Copper	0.14	2.458E-04
Iron	0.31	5.383E-04
Indium	0.00	0.000E+00
Potassium	219.45	3.777E-01
Magnesium	1.47	2.538E-03
Manganese	0.21	3.639E-04
Sodium	14.91	2.566E-02
Nickel	0.01	1.386E-05
Phosphorous	0.00	0.000E+00
Lead	0.11	1.850E-04
Rubidium	0.24	4.087E-04
Sulfur	43.69	7.518E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.05	8.563E-05
Titanium	0.01	9.871E-06
Vanadium	0.00	0.000E+00
Zinc	27.05	4.656E-02
Zirconium	0.02	3.113E-05

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	396.68	6.091E-01
Organic Carbon	4408.43	6.769E+00

Appliance:	EPA OWHH	Burn Rate:	High	Run #:	10
Fuel:	Spruce	Date:	3/23/2011		

Filter Information:

T1 ID #:	A7517988
T1 Flow Rate [mL/min]:	798
T1 Sample Volume [dsft^3]:	*6.65*
Q1 ID #:	A751850V
Q1 Flow Rate [mL/min]:	1051
Q1 Sample Volume [dsft^3]:	*8.76*

Run Information:

Test Duration [min]:	237
Tunnel Flow [dsft^3/min]:	462.0291
Barometric Pressure [in Hg]:	29.76
Temperature [℉]	68
Avg Delta H [in H2O]:	0.48

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**1228.00**	**5.120E+00**
K^+	248.29	1.035E+00
Na^+	2.72	1.135E-02
NH_4^+	-0.73	-3.054E-03
NO_3	10.25	4.272E-02
SO_4	150.09	6.258E-01
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.05	1.937E-04
Barium	0.87	3.617E-03
Bromine	0.25	1.025E-03
Calcium	32.02	1.335E-01
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	29.43	1.227E-01
Cobalt	0.05	1.938E-04
Chromium	0.57	2.357E-03
Cesium	0.00	0.000E+00
Copper	0.21	8.814E-04
Iron	1.10	4.577E-03
Indium	0.00	0.000E+00
Potassium	330.54	1.378E+00
Magnesium	4.27	1.781E-02
Manganese	1.25	5.192E-03
Sodium	14.19	5.916E-02
Nickel	0.01	4.222E-05
Phosphorous	1.48	6.157E-03
Lead	0.24	9.917E-04
Rubidium	0.35	1.454E-03
Sulfur	80.65	3.363E-01
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.20	8.541E-04
Titanium	0.00	0.000E+00
Vanadium	0.00	1.439E-05
Zinc	22.14	9.232E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	78.28	2.478E-01
Organic Carbon	623.86	1.975E+00

Appliance:	EPA OWHH	Burn Rate:	Low	Run #:	11
Fuel:	Spruce	Date:	3/24/2011		

Filter Information:

T1 ID #:	
T1 Flow Rate [mL/min]:	914.5
T1 Sample Volume [$dsft^3$]:	*18.79*
Q1 ID #:	A751844X
Q1 Flow Rate [mL/min]:	1116.7
Q1 Sample Volume [$dsft^3$]:	*22.94*

Run Information:

Test Duration [min]:	582
Tunnel Flow [$dsft^3$/min]:	479.7847
Barometric Pressure [in Hg]:	29.72
Temperature [℉]	65
Avg Delta H [in H2O]:	0.43

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**2819.00**	**4.319E+00**
K^+	119.17	1.826E-01
Na^+	1.55	2.381E-03
NH_4^+	0.23	3.555E-04
NO_3	7.65	1.172E-02
SO_4	48.75	7.469E-02
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.07	1.115E-04
Bromine	0.14	2.079E-04
Calcium	3.72	5.693E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	20.88	3.199E-02
Cobalt	0.02	3.802E-05
Chromium	0.05	7.213E-05
Cesium	0.00	0.000E+00
Copper	0.08	1.302E-04
Iron	0.17	2.627E-04
Indium	0.00	0.000E+00
Potassium	115.50	1.770E-01
Magnesium	0.75	1.145E-03
Manganese	0.24	3.691E-04
Sodium	11.05	1.693E-02
Nickel	0.02	3.488E-05
Phosphorous	0.00	0.000E+00
Lead	0.07	1.126E-04
Rubidium	0.15	2.252E-04
Sulfur	24.40	3.738E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.01	1.731E-05
Strontium	0.03	5.196E-05
Titanium	0.00	7.000E-06
Vanadium	0.00	0.000E+00
Zinc	21.28	3.260E-02
Zirconium	0.01	2.078E-05

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	41.62	5.223E-02
Organic Carbon	321.87	4.038E-01

Appliance:	Conventional Wood Stove	Burn Rate:	High	Run #:	12
Fuel:	Spruce	Date:	3/30/2011		

Filter Information:

T1 ID #:	A751826V
T1 Flow Rate [mL/min]:	857.52
T1 Sample Volume [dsft^3]:	*1.61*
Q1 ID #:	A751840T
Q1 Flow Rate [mL/min]:	901.43
Q1 Sample Volume [dsft^3]:	*1.69*

Run Information:

Test Duration [min]:	53
Tunnel Flow [dsft^3/min]:	444.7836
Barometric Pressure [in Hg]:	30.32
Temperature [℉]	75
Avg Delta H [in H2O]:	0.62

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**174.00**	**2.890E+00**
K^+	22.40	3.719E-01
Na^+	0.28	4.692E-03
NH_4^+	0.00	0.000E+00
NO_3	2.74	4.548E-02
SO_4	17.49	2.904E-01
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.04	6.582E-04
Bromine	0.03	5.631E-04
Calcium	2.90	4.824E-02
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	3.71	6.165E-02
Cobalt	0.01	1.521E-04
Chromium	0.01	2.424E-04
Cesium	0.00	0.000E+00
Copper	0.00	0.000E+00
Iron	0.63	1.039E-02
Indium	0.00	0.000E+00
Potassium	24.88	4.132E-01
Magnesium	0.54	8.915E-03
Manganese	0.08	1.386E-03
Sodium	2.77	4.593E-02
Nickel	0.01	2.159E-04
Phosphorous	0.00	0.000E+00
Lead	0.05	9.010E-04
Rubidium	0.01	1.126E-04
Sulfur	8.09	1.343E-01
Antimony	0.00	0.000E+00
Selenium	0.00	4.318E-05
Silicon	0.00	0.000E+00
Tin	0.15	2.440E-03
Strontium	0.04	6.194E-04
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	3.29	5.471E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	23.96	3.785E-01
Organic Carbon	95.09	1.502E+00

Appliance:	Conventional Wood Stove	**Burn Rate:**	High	**Run #:**	13
Fuel:	Birch	**Date:**	3/31/2011		

Filter Information:

T1 ID #:	A751814R & A751825U
T1 Flow Rate [mL/min]:	644.48
T1 Sample Volume [dsft^3]:	*0.91*
Q1 ID #:	A7518390
Q1 Flow Rate [mL/min]:	802.76
Q1 Sample Volume [dsft^3]:	*1.13*

Run Information:

Test Duration [min]:	40
Tunnel Flow [dsft^3/min]:	433.3931
Barometric Pressure [in Hg]:	30.32
Temperature [°F]	76
Avg Delta H [in H2O]:	0.59

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**3308.00**	**9.456E+01**
K^+	30.31	8.663E-01
Na^+	0.76	2.175E-02
NH_4^+	0.20	5.730E-03
NO_3	5.10	1.457E-01
SO_4	15.79	4.513E-01
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.00	0.000E+00
Barium	0.02	6.475E-04
Bromine	0.06	1.755E-03
Calcium	0.78	2.217E-02
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	8.63	2.468E-01
Cobalt	0.05	1.442E-03
Chromium	0.04	1.008E-03
Cesium	0.00	0.000E+00
Copper	0.04	1.263E-03
Iron	0.35	9.923E-03
Indium	0.00	0.000E+00
Potassium	43.02	1.230E+00
Magnesium	0.30	8.620E-03
Manganese	0.06	1.756E-03
Sodium	4.87	1.391E-01
Nickel	0.07	1.859E-03
Phosphorous	0.00	0.000E+00
Lead	0.05	1.487E-03
Rubidium	0.03	7.432E-04
Sulfur	12.20	3.486E-01
Antimony	0.00	0.000E+00
Selenium	0.01	2.328E-04
Silicon	0.32	9.244E-03
Tin	0.00	0.000E+00
Strontium	0.02	6.786E-04
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	7.33	2.096E-01
Zirconium	0.00	0.000E+00

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon	23.96	5.498E-01
Organic Carbon	95.09	2.182E+00

Appliance:	Conventional Wood Stove	**Burn Rate:**	Low	**Run #:**	14
Fuel:	Spruce	**Date:**	4/1/2011		

Filter Information:

T1 ID #:	A751815S
T1 Flow Rate [mL/min]:	756
T1 Sample Volume [dsft^3]:	*1.40*
Q1 ID #:	A751832T
Q1 Flow Rate [mL/min]:	937
Q1 Sample Volume [dsft^3]:	*1.74*

Run Information:

Test Duration [min]:	53
Tunnel Flow [dsft^3/min]:	459.842
Barometric Pressure [in Hg]:	29.96
Temperature [°F]	74
Avg Delta H [in H2O]:	0.55

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**757.00**	**1.489E+01**
K^+	37.93	7.463E-01
Na^+	0.37	7.194E-03
NH_4^+	0.00	0.000E+00
NO_3	2.84	5.595E-02
SO_4	15.78	3.105E-01
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.01	2.224E-04
Barium	0.00	0.000E+00
Bromine	0.04	7.562E-04
Calcium	0.29	5.709E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	4.90	9.642E-02
Cobalt	0.01	2.004E-04
Chromium	0.00	3.568E-05
Cesium	0.00	0.000E+00
Copper	0.00	0.000E+00
Iron	0.04	8.732E-04
Indium	0.00	0.000E+00
Potassium	44.15	8.687E-01
Magnesium	0.01	1.241E-04
Manganese	0.02	4.725E-04
Sodium	1.98	3.896E-02
Nickel	0.00	0.000E+00
Phosphorous	0.00	0.000E+00
Lead	0.02	4.226E-04
Rubidium	0.01	1.112E-04
Sulfur	9.71	1.910E-01
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	2.76	5.428E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	131.11	2.081E+00
Organic Carbon	669.43	1.063E+01

Appliance:	Conventional Wood Stove	**Burn Rate:**	Low	**Run #:**	15
Fuel:	Birch	**Date:**	4/1/2011		

Filter Information:

T1 ID #:	A751816T
T1 Flow Rate [mL/min]:	783
T1 Sample Volume [dsft^3]:	*1.34*
Q1 ID #:	A751836X
Q1 Flow Rate [mL/min]:	997
Q1 Sample Volume [dsft^3]:	*1.70*

Run Information:

Test Duration [min]:	49
Tunnel Flow [dsft^3/min]:	446.1507
Barometric Pressure [in Hg]:	29.98
Temperature [°F]	77
Avg Delta H [in H2O]:	0.55

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**2242.00**	**4.492E+01**
K^+	36.48	7.310E-01
Na^+	0.30	5.926E-03
NH_4^+	0.00	-2.363E-05
NO_3	1.52	3.047E-02
SO_4	14.23	2.852E-01
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.01	1.587E-04
Barium	0.00	0.000E+00
Bromine	0.05	9.063E-04
Calcium	0.16	3.291E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	5.17	1.035E-01
Cobalt	0.01	2.067E-04
Chromium	0.00	0.000E+00
Cesium	0.00	0.000E+00
Copper	0.00	0.000E+00
Iron	0.00	7.500E-05
Indium	0.00	0.000E+00
Potassium	49.03	9.823E-01
Magnesium	0.15	3.028E-03
Manganese	0.06	1.242E-03
Sodium	4.63	9.271E-02
Nickel	0.01	1.930E-04
Phosphorous	0.00	0.000E+00
Lead	0.02	3.625E-04
Rubidium	0.05	9.061E-04
Sulfur	15.10	3.026E-01
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	7.64	1.531E-01
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	455.07	7.160E+00
Organic Carbon	1970.65	3.101E+01

Appliance:	Oil Burner	Burn Rate:	Single	Run #:	17
Fuel:	No 2 Fuel Oil	Date:	4/12/2011		

Filter Information:

T1 ID #:	A751818V
T1 Flow Rate [mL/min]:	872.12
T1 Sample Volume [$dsft^3$]:	15.93
Q1 ID #:	A751833U
Q1 Flow Rate [mL/min]:	1086.6
Q1 Sample Volume [$dsft^3$]:	19.84

Run Information:

Test Duration [min]:	519
Tunnel Flow [$dsft^3$/min]:	487.5126
Barometric Pressure [in Hg]:	30.24
Temperature [°F]	76
Avg Delta H [in H2O]:	0.45

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**137.00**	**2.516E-01**
K^+	0.00	0.000E+00
Na^+	0.28	5.147E-04
NH_4^+	11.52	2.116E-02
NO_3	1.13	2.070E-03
SO_4	53.59	9.842E-02
Silver	0.00	0.000E+00
Aluminum	0.15	2.833E-04
Arsenic	0.00	0.000E+00
Barium	0.00	0.000E+00
Bromine	0.00	8.302E-06
Calcium	0.19	3.474E-04
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.08	1.397E-04
Cobalt	0.01	9.759E-06
Chromium	0.02	3.842E-05
Cesium	0.00	2.078E-06
Copper	0.06	1.156E-04
Iron	0.18	3.386E-04
Indium	0.00	0.000E+00
Potassium	0.07	1.374E-04
Magnesium	0.00	0.000E+00
Manganese	0.01	2.118E-05
Sodium	0.00	0.000E+00
Nickel	0.07	1.268E-04
Phosphorous	0.00	0.000E+00
Lead	0.00	0.000E+00
Rubidium	0.00	0.000E+00
Sulfur	19.56	3.592E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.09	1.673E-04
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.02	3.740E-05
Vanadium	0.00	0.000E+00
Zinc	0.02	2.844E-05
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	6.84	1.009E-02
Organic Carbon	44.60	6.574E-02

Appliance:	Waste Oil Burner	Burn Rate:	Single	Run #:	18
Fuel:	Waste Oil	Date:	4/14/2011		

Filter Information:

T1 ID #:	A751824T
T1 Flow Rate [mL/min]:	3754
T1 Sample Volume [dsft^3]:	*21.58*
Q1 ID #:	A751829Y
Q1 Flow Rate [mL/min]:	3699
Q1 Sample Volume [dsft^3]:	*21.27*

Run Information:

Test Duration [min]:	163
Tunnel Flow [dsft^3/min]:	445.7873
Barometric Pressure [in Hg]:	30.14
Temperature [°F]	72.95
Avg Delta H [in H2O]:	0.4752

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**8402.00**	**1.041E+01**
K^+	337.71	**4.185E-01**
Na^+	564.26	**6.993E-01**
NH_4^+	0.00	**0.000E+00**
NO_3	556.29	**6.894E-01**
SO_4	461.95	**5.725E-01**
Silver		No Data
Aluminum	6.66	**8.250E-03**
Arsenic		No Data
Barium		No Data
Bromine	1.83	**2.264E-03**
Calcium	181.47	**2.249E-01**
Cadmium		No Data
Cerium		No Data
Chlorine	1791.18	**2.220E+00**
Cobalt		No Data
Chromium		No Data
Cesium		No Data
Copper		No Data
Iron	43.96	**5.449E-02**
Indium		No Data
Potassium	370.56	**4.592E-01**
Magnesium	19.22	**2.381E-02**
Manganese		No Data
Sodium		No Data
Nickel		No Data
Phosphorous	700.04	**8.676E-01**
Lead	14.71	**1.823E-02**
Rubidium	0.00	**0.000E+00**
Sulfur	187.50	**2.324E-01**
Antimony		No Data
Selenium		No Data
Silicon	2.39	**2.966E-03**
Tin		No Data
Strontium		No Data
Titanium		No Data
Vanadium		No Data
Zinc	1349.93	**1.673E+00**
Zirconium		No Data

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	21.47	2.700E-02
Organic Carbon	79.42	9.989E-02

Appliance:	Coal Stove	Burn Rate:	High	Run #:	20
Fuel:	Dry Stoker Coal	Date:	5/6/2011		

Filter Information:

T1 ID #:	A751822R
T1 Flow Rate [mL/min]:	223
T1 Sample Volume [dsft^3]:	*1.62*
Q1 ID #:	A751828X
Q1 Flow Rate [mL/min]:	849
Q1 Sample Volume [dsft^3]:	*6.18*

Run Information:

Test Duration [min]:	208
Tunnel Flow [dsft^3/min]:	460.1363
Barometric Pressure [in Hg]:	30.14
Temperature [°F]	76.7
Avg Delta H [in H2O]:	0.4528

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**1027.00**	**1.745E+01**
K^+	0.17	**2.867E-03**
Na^+	0.21	**3.545E-03**
NH_4^+	0.82	**1.394E-02**
NO_3	0.83	**1.418E-02**
SO_4	3.09	**5.244E-02**
Silver	0.00	**0.000E+00**
Aluminum	0.09	**1.566E-03**
Arsenic	0.04	**6.724E-04**
Barium	0.00	**0.000E+00**
Bromine	0.10	**1.748E-03**
Calcium	0.13	**2.170E-03**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	5.76	**9.791E-02**
Cobalt	0.00	**0.000E+00**
Chromium	0.01	**1.290E-04**
Cesium	0.00	**0.000E+00**
Copper	0.00	**6.343E-05**
Iron	0.15	**2.566E-03**
Indium	0.00	**0.000E+00**
Potassium	0.19	**3.264E-03**
Magnesium	0.00	**0.000E+00**
Manganese	0.00	**0.000E+00**
Sodium	0.00	**0.000E+00**
Nickel	0.00	**0.000E+00**
Phosphorous	0.00	**0.000E+00**
Lead	0.48	**8.184E-03**
Rubidium	0.00	**0.000E+00**
Sulfur	8.99	**1.527E-01**
Antimony	0.40	**6.722E-03**
Selenium	0.04	**5.975E-04**
Silicon	0.06	**9.742E-04**
Tin	0.00	**0.000E+00**
Strontium	0.00	**0.000E+00**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	0.89	**1.516E-02**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	693.05	3.094E+00
Organic Carbon	1620.49	7.234E+00

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	21
Fuel:	Dry Stoker Coal	**Date:**	5/9/2011		

Filter Information:

T1 ID #:	A751821Q
T1 Flow Rate [mL/min]:	780.81
T1 Sample Volume [dsft^3]:	*10.82*
Q1 ID #:	A751837Y
Q1 Flow Rate [mL/min]:	893.53
Q1 Sample Volume [dsft^3]:	*12.38*

Run Information:

Test Duration [min]:	391
Tunnel Flow [dsft^3/min]:	478.2646
Barometric Pressure [in Hg]:	30.2
Temperature [°F]	71.46
Avg Delta H [in H2O]:	0.442

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**655.00**	**1.737E+00**
K^+	0.00	**0.000E+00**
Na^+	0.17	**4.488E-04**
NH_4^+	2.32	**6.163E-03**
NO_3	0.92	**2.447E-03**
SO_4	6.48	**1.719E-02**
Silver	0.00	**0.000E+00**
Aluminum	0.01	**2.846E-05**
Arsenic	0.02	**4.796E-05**
Barium	0.00	**0.000E+00**
Bromine	0.02	**5.336E-05**
Calcium	0.01	**1.507E-05**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	0.50	**1.320E-03**
Cobalt	0.00	**1.020E-05**
Chromium	0.00	**0.000E+00**
Cesium	0.00	**0.000E+00**
Copper	0.04	**1.097E-04**
Iron	0.06	**1.689E-04**
Indium	0.01	**2.997E-05**
Potassium	0.00	**0.000E+00**
Magnesium	0.00	**0.000E+00**
Manganese	0.00	**0.000E+00**
Sodium	0.00	**0.000E+00**
Nickel	0.00	**0.000E+00**
Phosphorous	0.00	**0.000E+00**
Lead	0.04	**9.892E-05**
Rubidium	0.00	**0.000E+00**
Sulfur	3.60	**9.541E-03**
Antimony	0.00	**0.000E+00**
Selenium	0.01	**1.499E-05**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.00	**0.000E+00**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	0.06	**1.682E-04**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	267.46	6.199E-01
Organic Carbon	1417.80	3.286E+00

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	23
Fuel:	Wet Stoker Coal	Date:	5/11/2011		

Filter Information:

T1 ID #:	A751820P
T1 Flow Rate [mL/min]:	142.9
T1 Sample Volume [dsft^3]:	1.47
Q1 ID #:	A7518492
Q1 Flow Rate [mL/min]:	896.63
Q1 Sample Volume [dsft^3]:	9.21

Run Information:

Test Duration [min]:	294
Tunnel Flow [dsft^3/min]:	467.5876
Barometric Pressure [in Hg]:	29.97
Temperature [°F]	75.0131
Avg Delta H [in H2O]:	0.4214

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**582.00**	**1.113E+01**
K^+	**0.00**	0.000E+00
Na^+	0.23	4.325E-03
NH_4^+	0.75	1.431E-02
NO_3	3.60	6.891E-02
SO_4	3.06	5.854E-02
Silver	0.00	0.000E+00
Aluminum	0.04	6.797E-04
Arsenic	0.01	2.809E-04
Barium	0.00	0.000E+00
Bromine	0.00	6.481E-06
Calcium	0.07	1.411E-03
Cadmium	0.07	1.296E-03
Cerium	0.00	0.000E+00
Chlorine	0.46	8.799E-03
Cobalt	0.01	1.319E-04
Chromium	0.00	0.000E+00
Cesium	0.08	1.624E-03
Copper	0.00	0.000E+00
Iron	0.10	1.848E-03
Indium	0.08	1.512E-03
Potassium	0.08	1.521E-03
Magnesium	0.00	0.000E+00
Manganese	0.00	0.000E+00
Sodium	0.00	0.000E+00
Nickel	0.01	2.637E-04
Phosphorous	0.00	0.000E+00
Lead	0.01	1.728E-04
Rubidium	0.00	9.505E-05
Sulfur	1.65	3.163E-02
Antimony	0.00	0.000E+00
Selenium	0.00	7.779E-05
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.02	4.762E-04
Vanadium	0.01	2.164E-04
Zinc	0.07	1.346E-03
Zirconium	0.05	8.641E-04

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	167.08	5.090E-01
Organic Carbon	2367.08	7.212E+00

Appliance:	Non Qualified OWHH	**Burn Rate:**	High	**Run #:**	25
Fuel:	Spruce	**Date:**	5/27/2011		

Filter Information:

T1 ID #:	A7583519
T1 Flow Rate [mL/min]:	168.8
T1 Sample Volume [dsft^3]:	*0.70*
Q1 ID #:	A7518470
Q1 Flow Rate [mL/min]:	924.45
Q1 Sample Volume [dsft^3]:	*3.86*

Run Information:

Test Duration [min]:	118
Tunnel Flow [dsft^3/min]:	387.2835
Barometric Pressure [in Hg]:	29.99
Temperature [°F]	68.3866
Avg Delta H [in H2O]:	0.4198

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**3946.00**	**1.301E+02**
K^+	64.11	**2.113E+00**
Na^+	0.87	**2.868E-02**
NH_4^+	0.00	**0.000E+00**
NO_3	2.92	**9.614E-02**
SO_4	19.20	**6.328E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.00	**0.000E+00**
Arsenic	0.00	**0.000E+00**
Barium	0.00	**0.000E+00**
Bromine	0.07	**2.312E-03**
Calcium	0.95	**3.136E-02**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	11.62	**3.831E-01**
Cobalt	0.01	**4.868E-04**
Chromium	0.01	**2.220E-04**
Cesium	0.00	**0.000E+00**
Copper	0.13	**4.258E-03**
Iron	0.20	**6.561E-03**
Indium	0.01	**3.726E-04**
Potassium	72.77	**2.399E+00**
Magnesium	0.29	**9.466E-03**
Manganese	0.06	**1.956E-03**
Sodium	7.71	**2.540E-01**
Nickel	0.01	**4.302E-04**
Phosphorous	0.00	**0.000E+00**
Lead	0.02	**5.594E-04**
Rubidium	0.05	**1.603E-03**
Sulfur	8.89	**2.931E-01**
Antimony	0.00	**0.000E+00**
Selenium	0.00	**0.000E+00**
Silicon	0.07	**2.343E-03**
Tin	0.31	**1.006E-02**
Strontium	0.01	**2.237E-04**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	6.26	**2.062E-01**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon	1717.98	1.034E+01
Organic Carbon	7290.90	4.388E+01

Appliance:	Non Qualified OWHH	Burn Rate:	Low	Run #:	26
Fuel:	Wet Stoker Coal	Date:	5/30/2011		

Filter Information:

T1 ID #:	A7583508
T1 Flow Rate [mL/min]:	130.9
T1 Sample Volume [$dsft^3$]:	0.57
Q1 ID #:	A751838Z
Q1 Flow Rate [mL/min]:	1037.6
Q1 Sample Volume [$dsft^3$]:	4.50

Run Information:

Test Duration [min]:	123
Tunnel Flow [$dsft^3$/min]:	424.9401
Barometric Pressure [in Hg]:	29.98
Temperature [°F]	69.9032
Avg Delta H [in H2O]:	0.4735

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	6564.00	2.946E+02
K^+	4.62	2.074E-01
Na^+	0.48	2.146E-02
NH_4^+	1.03	4.630E-02
NO_3	0.75	3.363E-02
SO_4	16.02	7.192E-01
Silver	0.00	0.000E+00
Aluminum	0.32	1.439E-02
Arsenic	0.10	4.523E-03
Barium	0.00	0.000E+00
Bromine	0.17	7.619E-03
Calcium	0.82	3.678E-02
Cadmium	0.06	2.537E-03
Cerium	0.00	0.000E+00
Chlorine	1.53	6.887E-02
Cobalt	0.01	5.771E-04
Chromium	0.01	4.627E-04
Cesium	0.05	2.339E-03
Copper	0.23	1.031E-02
Iron	0.59	2.655E-02
Indium	0.00	0.000E+00
Potassium	6.76	3.036E-01
Magnesium	0.00	0.000E+00
Manganese	0.05	2.297E-03
Sodium	4.67	2.094E-01
Nickel	0.02	8.568E-04
Phosphorous	0.00	0.000E+00
Lead	0.20	9.194E-03
Rubidium	0.03	1.422E-03
Sulfur	21.57	9.678E-01
Antimony	0.00	0.000E+00
Selenium	0.00	1.016E-04
Silicon	0.00	2.126E-04
Tin	0.00	0.000E+00
Strontium	0.03	1.168E-03
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	0.70	3.141E-02
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon		No Data
Organic Carbon		No Data

Appliance:	Non-Qualified OWHH	Burn Rate:	Low	Run #:	27
Fuel:	Coal with Retrofit Catalyst	Date:	6/1/2011		

Filter Information:

T1 ID #:	A758338C
T1 Flow Rate [mL/min]:	178.21
T1 Sample Volume [dsft^3]:	1.24
Q1 ID #:	A751846Z
Q1 Flow Rate [mL/min]:	1017
Q1 Sample Volume [dsft^3]:	7.08

Run Information:

Test Duration [min]:	196
Tunnel Flow [dsft^3/min]:	426.929
Barometric Pressure [in Hg]:	30.15
Temperature [°F]	69.7107
Avg Delta H [in H2O]:	0.4826

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**5815.00**	**1.201E+02**
K^+	0.90	**1.852E-02**
Na^+	0.45	**9.383E-03**
NH_4^+	0.35	**7.138E-03**
NO_3	0.36	**7.417E-03**
SO_4	9.88	**2.041E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.68	**1.399E-02**
Arsenic	0.06	**1.263E-03**
Barium	0.00	**0.000E+00**
Bromine	0.06	**1.239E-03**
Calcium	0.20	**4.083E-03**
Cadmium	0.10	**2.102E-03**
Cerium	0.00	**0.000E+00**
Chlorine	0.41	**8.453E-03**
Cobalt	0.00	**6.812E-05**
Chromium	0.02	**5.009E-04**
Cesium	0.00	**0.000E+00**
Copper	0.05	**9.681E-04**
Iron	0.27	**5.492E-03**
Indium	0.00	**0.000E+00**
Potassium	1.33	**2.757E-02**
Magnesium	0.00	**0.000E+00**
Manganese	0.00	**0.000E+00**
Sodium	1.52	**3.131E-02**
Nickel	0.01	**1.877E-04**
Phosphorous	0.00	**0.000E+00**
Lead	0.30	**6.102E-03**
Rubidium	0.01	**1.168E-04**
Sulfur	17.99	**3.716E-01**
Antimony	0.00	**0.000E+00**
Selenium	0.01	**2.572E-04**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.00	**0.000E+00**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	0.43	**8.902E-03**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon		No Data
Organic Carbon		No Data

Appliance:	Coal HH	Burn Rate:	Single, Cold Start	Run #:	28
Fuel:	Coal (typical moisture)	Date:	6/7/2011		

Filter Information:

T1 ID #:	A758349F
T1 Flow Rate [mL/min]:	183.52
T1 Sample Volume [dsft^3]:	*1.28*
Q1 ID #:	A751835W
Q1 Flow Rate [mL/min]:	979.11
Q1 Sample Volume [dsft^3]:	*6.84*

Run Information:

Test Duration [min]:	199
Tunnel Flow [dsft^3/min]:	427.5965
Barometric Pressure [in Hg]:	30.13
Temperature [°F]	74.98
Avg Delta H [in H2O]:	0.48

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**364.00**	**7.280E+00**
K^+	14.23	2.846E-01
Na^+	15.92	3.185E-01
NH_4^+	14.04	2.807E-01
NO_3	1.72	3.433E-02
SO_4	153.86	3.077E+00
Silver	0.00	0.000E+00
Aluminum	1.47	2.946E-02
Arsenic	0.10	2.080E-03
Barium	0.27	5.330E-03
Bromine	0.01	2.487E-04
Calcium	5.60	1.121E-01
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.14	2.819E-03
Cobalt	0.03	6.313E-04
Chromium	0.19	3.828E-03
Cesium	0.05	9.983E-04
Copper	0.98	1.957E-02
Iron	4.74	9.488E-02
Indium	0.00	0.000E+00
Potassium	13.00	2.600E-01
Magnesium	0.73	1.453E-02
Manganese	0.15	2.939E-03
Sodium	15.55	3.110E-01
Nickel	0.10	2.030E-03
Phosphorous	0.26	5.284E-03
Lead	1.73	3.452E-02
Rubidium	0.07	1.447E-03
Sulfur	47.50	9.499E-01
Antimony	0.00	0.000E+00
Selenium	0.03	6.783E-04
Silicon	1.90	3.791E-02
Tin	0.00	0.000E+00
Strontium	0.06	1.153E-03
Titanium	0.06	1.293E-03
Vanadium	0.00	9.067E-05
Zinc	2.53	5.058E-02
Zirconium	0.03	6.781E-04

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	39.95	1.497E-01
Organic Carbon	184.95	6.933E-01

Appliance:	Coal HH	Burn Rate:	Single	Run #:	29
Fuel:	Wet Stoker Coal	Date:	6/7/2011		

Filter Information:

T1 ID #:	A7583406
T1 Flow Rate [mL/min]:	160.56
T1 Sample Volume [dsft^3]:	1.13
Q1 ID #:	A751834V
Q1 Flow Rate [mL/min]:	1029.4
Q1 Sample Volume [dsft^3]:	7.27

Run Information:

Test Duration [min]:	202
Tunnel Flow [dsft^3/min]:	410.0643
Barometric Pressure [in Hg]:	30.13
Temperature [°F]	77.6453
Avg Delta H [in H2O]:	0.49

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**355.00**	**7.705E+00**
K^+	12.99	2.820E-01
Na^+	14.90	3.234E-01
NH_4^+	9.31	2.020E-01
NO_3	1.91	4.149E-02
SO_4	141.80	3.078E+00
Silver	0.00	0.000E+00
Aluminum	2.61	5.659E-02
Arsenic	0.23	5.006E-03
Barium	0.42	9.036E-03
Bromine	0.11	2.478E-03
Calcium	10.91	2.367E-01
Cadmium	0.00	0.000E+00
Cerium	0.00	2.460E-05
Chlorine	0.24	5.102E-03
Cobalt	0.05	1.130E-03
Chromium	0.21	4.475E-03
Cesium	0.00	0.000E+00
Copper	1.16	2.517E-02
Iron	7.81	1.695E-01
Indium	0.00	0.000E+00
Potassium	13.59	2.949E-01
Magnesium	1.41	3.055E-02
Manganese	0.18	4.006E-03
Sodium	16.67	3.617E-01
Nickel	0.15	3.200E-03
Phosphorous	0.20	4.392E-03
Lead	1.90	4.125E-02
Rubidium	0.09	1.938E-03
Sulfur	46.51	1.010E+00
Antimony	0.19	4.170E-03
Selenium	0.04	8.343E-04
Silicon	4.77	1.035E-01
Tin	0.00	0.000E+00
Strontium	0.11	2.355E-03
Titanium	0.16	3.374E-03
Vanadium	0.05	9.842E-04
Zinc	2.38	5.158E-02
Zirconium	0.15	3.189E-03

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	41.08	1.391E-01
Organic Carbon	187.91	6.361E-01

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	30
Fuel:	Spruce	**Date:**	6/30/2011		

Filter Information:

T1 ID #:	A7583417
T1 Flow Rate [mL/min]:	200.7
T1 Sample Volume [dsft^3]:	*0.82*
Q1 ID #:	A751831S
Q1 Flow Rate [mL/min]:	997.4
Q1 Sample Volume [dsft^3]:	*4.08*

Run Information:

Test Duration [min]:	117
Tunnel Flow [dsft^3/min]:	412.9687
Barometric Pressure [in Hg]:	30.16
Temperature [°F]	78.439
Avg Delta H [in H2O]:	0.4357

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**5514.00**	**1.666E+02**
K^+	27.50	**8.308E-01**
Na^+	1.20	**3.622E-02**
NH_4^+	0.25	**7.522E-03**
NO_3	1.53	**4.620E-02**
SO_4	6.79	**2.050E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.00	**0.000E+00**
Arsenic	0.01	**2.736E-04**
Barium	0.00	**0.000E+00**
Bromine	0.08	**2.290E-03**
Calcium	0.60	**1.803E-02**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	4.34	**1.310E-01**
Cobalt	0.00	**1.477E-04**
Chromium	0.00	**0.000E+00**
Cesium	0.00	**0.000E+00**
Copper	0.28	**8.563E-03**
Iron	0.10	**2.903E-03**
Indium	0.00	**0.000E+00**
Potassium	36.99	**1.118E+00**
Magnesium	0.09	**2.737E-03**
Manganese	0.02	**6.479E-04**
Sodium	4.64	**1.402E-01**
Nickel	0.00	**1.441E-04**
Phosphorous	0.00	**0.000E+00**
Lead	0.04	**1.197E-03**
Rubidium	0.02	**5.809E-04**
Sulfur	3.06	**9.240E-02**
Antimony	0.02	**6.829E-04**
Selenium	0.01	**2.188E-04**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.00	**0.000E+00**
Titanium	0.02	**6.271E-04**
Vanadium	0.00	**1.387E-04**
Zinc	5.24	**1.582E-01**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon		No Data
Organic Carbon		No Data

Appliance:	Non Qualified OWHH	**Burn Rate:**	High	**Run #:**	31
Fuel:	Birch	**Date:**	7/1/2011		

Filter Information:

T1 ID #:	A758339D
T1 Flow Rate [mL/min]:	211.3
T1 Sample Volume [dsft^3]:	*0.86*
Q1 ID #:	A768262E
Q1 Flow Rate [mL/min]:	997.4
Q1 Sample Volume [dsft^3]:	*4.04*

Run Information:

Test Duration [min]:	115
Tunnel Flow [dsft^3/min]:	367.8844
Barometric Pressure [in Hg]:	30.21
Temperature [°F]	74.7845
Avg Delta H [in H2O]:	0.4263

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**4628.00**	**1.193E+02**
K^+	111.69	**2.880E+00**
Na^+	0.36	**9.180E-03**
NH_4^+	0.16	**4.000E-03**
NO_3	4.15	**1.071E-01**
SO_4	59.52	**1.535E+00**
Silver	0.15	**3.789E-03**
Aluminum	0.00	**0.000E+00**
Arsenic	0.01	**3.213E-04**
Barium	0.00	**0.000E+00**
Bromine	0.09	**2.335E-03**
Calcium	0.47	**1.222E-02**
Cadmium	0.03	**8.745E-04**
Cerium	0.00	**0.000E+00**
Chlorine	18.86	**4.864E-01**
Cobalt	0.01	**3.815E-04**
Chromium	0.00	**0.000E+00**
Cesium	0.00	**0.000E+00**
Copper	0.09	**2.214E-03**
Iron	0.05	**1.352E-03**
Indium	0.00	**0.000E+00**
Potassium	116.85	**3.013E+00**
Magnesium	0.60	**1.546E-02**
Manganese	0.08	**2.082E-03**
Sodium	25.62	**6.606E-01**
Nickel	0.00	**4.983E-05**
Phosphorous	0.00	**0.000E+00**
Lead	0.02	**4.963E-04**
Rubidium	0.08	**2.043E-03**
Sulfur	24.02	**6.193E-01**
Antimony	0.00	**0.000E+00**
Selenium	0.00	**0.000E+00**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.01	**3.501E-04**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	21.39	**5.516E-01**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon	1632.88	8.920E+00
Organic Carbon	6724.69	3.674E+01

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	32
Fuel:	Birch	**Date:**	7/6/2011		

Filter Information:

T1 ID #:	A7583428
T1 Flow Rate [mL/min]:	159.34
T1 Sample Volume [$dsft^3$]:	*1.26*
Q1 ID #:	A768261D
Q1 Flow Rate [mL/min]:	1030.9
Q1 Sample Volume [$dsft^3$]:	*8.18*

Run Information:

Test Duration [min]:	231
Tunnel Flow [$dsft^3$/min]:	413.0445
Barometric Pressure [in Hg]:	30.16
Temperature [°F]	87.5733
Avg Delta H [in H2O]:	0.4869

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**2269.00**	**4.447E+01**
K^+	24.55	**4.812E-01**
Na^+	0.19	**3.694E-03**
NH_4^+	0.18	**3.604E-03**
NO_3	1.75	**3.434E-02**
SO_4	12.39	**2.428E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.00	**0.000E+00**
Arsenic	0.01	**1.552E-04**
Barium	0.00	**0.000E+00**
Bromine	0.05	**1.020E-03**
Calcium	0.12	**2.377E-03**
Cadmium	0.23	**4.430E-03**
Cerium	0.00	**0.000E+00**
Chlorine	9.07	**1.779E-01**
Cobalt	0.00	**0.000E+00**
Chromium	0.03	**5.012E-04**
Cesium	0.00	**0.000E+00**
Copper	0.01	**2.730E-04**
Iron	0.09	**1.669E-03**
Indium	0.00	**0.000E+00**
Potassium	31.92	**6.256E-01**
Magnesium	0.14	**2.820E-03**
Manganese	0.00	**0.000E+00**
Sodium	5.45	**1.068E-01**
Nickel	0.00	**0.000E+00**
Phosphorous	0.00	**0.000E+00**
Lead	0.00	**0.000E+00**
Rubidium	0.04	**7.535E-04**
Sulfur	5.62	**1.102E-01**
Antimony	0.00	**0.000E+00**
Selenium	0.01	**1.352E-04**
Silicon	0.00	**0.000E+00**
Tin	0.17	**3.323E-03**
Strontium	0.01	**2.216E-04**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	8.34	**1.635E-01**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon		No Data
Organic Carbon		No Data

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	33
Fuel:	Birch, Cold Start	**Date:**	7/8/2011		

Filter Information:

T1 ID #:	A7583439
T1 Flow Rate [mL/min]:	145.4
T1 Sample Volume [dsft^3]:	*1.77*
Q1 ID #:	A768260C & A768259J
Q1 Flow Rate [mL/min]:	980.6
Q1 Sample Volume [dsft^3]:	*11.92*

Run Information:

Test Duration [min]:	346
Tunnel Flow [dsft^3/min]:	407.1146
Barometric Pressure [in Hg]:	30.26
Temperature [°F]	77.2133
Avg Delta H [in H2O]:	0.4393

Teflon Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Total $PM_{2.5}$	**2514.00**	**3.475E+01**
K^+	54.59	**7.546E-01**
Na^+	0.32	**4.455E-03**
NH_4^+	0.24	**3.267E-03**
NO_3	2.11	**2.914E-02**
SO_4	17.83	**2.465E-01**
Silver	0.02	**3.125E-04**
Aluminum	0.00	**0.000E+00**
Arsenic	0.00	**6.257E-05**
Barium	0.00	**0.000E+00**
Bromine	0.10	**1.423E-03**
Calcium	0.59	**8.195E-03**
Cadmium	0.07	**9.374E-04**
Cerium	0.02	**2.523E-04**
Chlorine	26.11	**3.610E-01**
Cobalt	0.05	**6.336E-04**
Chromium	0.27	**3.668E-03**
Cesium	0.00	**0.000E+00**
Copper	3.50	**4.831E-02**
Iron	2.92	**4.037E-02**
Indium	0.00	**0.000E+00**
Potassium	62.81	**8.681E-01**
Magnesium	0.64	**8.780E-03**
Manganese	0.09	**1.265E-03**
Sodium	14.91	**2.061E-01**
Nickel	0.12	**1.688E-03**
Phosphorous	0.00	**0.000E+00**
Lead	0.19	**2.690E-03**
Rubidium	0.04	**5.628E-04**
Sulfur	7.82	**1.081E-01**
Antimony	0.52	**7.186E-03**
Selenium	0.00	**6.263E-06**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.01	**1.094E-04**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	19.54	**2.700E-01**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	**Catch [µg]:**	**Emission Rate [g/hr]**
Elemental Carbon	2563.52	5.254E+00
Organic Carbon	8579.16	1.758E+01

Appliance:	EPA OWHH	Burn Rate:	Low	Run #:	34
Fuel:	Birch w/ Retrofit Catalyst	Date:	7/27/2011		

Filter Information:

T1 ID #:	A758346C
T1 Flow Rate [mL/min]:	180.3
T1 Sample Volume [$dsft^3$]:	3.35
Q1 ID #:	A768275J
Q1 Flow Rate [mL/min]:	1108.1
Q1 Sample Volume [$dsft^3$]:	20.59

Run Information:

Test Duration [min]:	534
Tunnel Flow [$dsft^3$/min]:	502.8851
Barometric Pressure [in Hg]:	30.21
Temperature [°F]	81.5533
Avg Delta H [in H2O]:	0.4472

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**3754.00**	**3.382E+01**
K^+	32.81	**2.955E-01**
Na^+	0.58	**5.252E-03**
NH_4^+	0.14	**1.226E-03**
NO_3	4.33	**3.902E-02**
SO_4	14.90	**1.343E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.00	**0.000E+00**
Arsenic	0.00	**0.000E+00**
Barium	0.00	**0.000E+00**
Bromine	0.09	**7.949E-04**
Calcium	0.51	**4.570E-03**
Cadmium	0.12	**1.120E-03**
Cerium	0.01	**1.338E-04**
Chlorine	12.69	**1.143E-01**
Cobalt	0.00	**2.454E-05**
Chromium	0.01	**1.325E-04**
Cesium	0.00	**0.000E+00**
Copper	0.12	**1.080E-03**
Iron	0.44	**3.952E-03**
Indium	0.27	**2.444E-03**
Potassium	35.44	**3.192E-01**
Magnesium	0.22	**1.977E-03**
Manganese	0.05	**4.265E-04**
Sodium	10.04	**9.043E-02**
Nickel	0.01	**5.517E-05**
Phosphorous	0.00	**0.000E+00**
Lead	0.04	**3.975E-04**
Rubidium	0.02	**1.936E-04**
Sulfur	5.79	**5.212E-02**
Antimony	0.00	**0.000E+00**
Selenium	0.00	**0.000E+00**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.00	**0.000E+00**
Titanium	0.00	**0.000E+00**
Vanadium	0.00	**0.000E+00**
Zinc	8.50	**7.661E-02**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	717.01	1.051E+00
Organic Carbon	1736.87	2.546E+00

Appliance:	Coal Stove	Burn Rate:	High	Run #:	35
Fuel:	Wet Stoker Coal	Date:	8/10/2011		

Filter Information:

T1 ID #:	A758345B
T1 Flow Rate [mL/min]:	172.5
T1 Sample Volume [dsft^3]:	*1.30*
Q1 ID #:	A768267J
Q1 Flow Rate [mL/min]:	998.4
Q1 Sample Volume [dsft^3]:	*7.54*

Run Information:

Test Duration [min]:	220
Tunnel Flow [dsft^3/min]:	469.458
Barometric Pressure [in Hg]:	30.08
Temperature [°F]	86.3213
Avg Delta H [in H2O]:	0.4683

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**362.00**	**7.825E+00**
K^+	0.19	**4.040E-03**
Na^+	0.17	**3.624E-03**
NH_4^+	0.45	**9.657E-03**
NO_3	0.53	**1.154E-02**
SO_4	3.18	**6.880E-02**
Silver	0.00	**0.000E+00**
Aluminum	0.00	**0.000E+00**
Arsenic	0.00	**2.442E-05**
Barium	0.00	**0.000E+00**
Bromine	0.02	**5.008E-04**
Calcium	0.06	**1.323E-03**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	0.11	**2.361E-03**
Cobalt	0.00	**2.442E-05**
Chromium	0.00	**0.000E+00**
Cesium	0.00	**0.000E+00**
Copper	0.00	**0.000E+00**
Iron	0.04	**8.699E-04**
Indium	0.00	**0.000E+00**
Potassium	0.06	**1.398E-03**
Magnesium	0.00	**0.000E+00**
Manganese	0.00	**0.000E+00**
Sodium	0.00	**0.000E+00**
Nickel	0.00	**5.376E-05**
Phosphorous	0.00	**0.000E+00**
Lead	0.13	**2.834E-03**
Rubidium	0.00	**0.000E+00**
Sulfur	1.79	**3.875E-02**
Antimony	0.45	**9.770E-03**
Selenium	0.00	**6.106E-05**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.02	**3.908E-04**
Titanium	0.01	**2.690E-04**
Vanadium	0.00	**0.000E+00**
Zinc	0.12	**2.555E-03**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	513.67	1.918E+00
Organic Carbon	987.70	3.689E+00

Appliance:	Coal Stove	Burn Rate:	Low, Cold Start	Run #:	36
Fuel:	Wet Lump Coal	Date:	8/11/2011		

Filter Information:

T1 ID #:	A779727Z
T1 Flow Rate [mL/min]:	162.85
T1 Sample Volume [dsft^3]:	2.82
Q1 ID #:	A768258I
Q1 Flow Rate [mL/min]:	1064.4
Q1 Sample Volume [dsft^3]:	18.46

Run Information:

Test Duration [min]:	497
Tunnel Flow [dsft^3/min]:	488.8577
Barometric Pressure [in Hg]:	30.14
Temperature [°F]	78.739
Avg Delta H [in H2O]:	0.4488

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	1571.00	1.632E+01
K^+	0.97	1.012E-02
Na^+	0.16	1.675E-03
NH_4^+	1.31	1.361E-02
NO_3	1.21	1.257E-02
SO_4	9.21	9.565E-02
Silver	0.00	0.000E+00
Aluminum	0.07	7.065E-04
Arsenic	0.06	5.754E-04
Barium	0.00	0.000E+00
Bromine	0.06	5.754E-04
Calcium	0.84	8.775E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.82	8.556E-03
Cobalt	0.00	1.059E-05
Chromium	0.02	2.273E-04
Cesium	0.00	0.000E+00
Copper	0.00	0.000E+00
Iron	0.15	1.538E-03
Indium	0.11	1.174E-03
Potassium	1.47	1.524E-02
Magnesium	0.02	1.899E-04
Manganese	0.08	8.520E-04
Sodium	0.00	0.000E+00
Nickel	0.01	5.994E-05
Phosphorous	0.00	0.000E+00
Lead	0.10	1.045E-03
Rubidium	0.01	5.400E-05
Sulfur	7.71	8.004E-02
Antimony	0.00	0.000E+00
Selenium	0.01	1.186E-04
Silicon	0.03	2.808E-04
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.01	1.298E-04
Vanadium	0.00	0.000E+00
Zinc	0.59	6.109E-03
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon		No Data
Organic Carbon		No Data

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	37
Fuel:	Wet Lump Coal	Date:	8/12/2011		

Filter Information:

T1 ID #:	A779726Y
T1 Flow Rate [mL/min]:	247.3
T1 Sample Volume [$dsft^3$]:	3.37
Q1 ID #:	A768266I
Q1 Flow Rate [mL/min]:	1002.9
Q1 Sample Volume [$dsft^3$]:	13.67

Run Information:

Test Duration [min]:	393
Tunnel Flow [$dsft^3$/min]:	488.5701
Barometric Pressure [in Hg]:	30.12
Temperature [°F]	81.5964
Avg Delta H [in H2O]:	0.4678

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	316.00	2.748E+00
K^+	0.60	5.223E-03
Na^+	0.93	8.102E-03
NH_4^+	0.73	6.348E-03
NO_3	0.59	5.092E-03
SO_4	3.83	3.328E-02
Silver	0.00	0.000E+00
Aluminum	0.29	2.552E-03
Arsenic	0.02	1.769E-04
Barium	0.00	0.000E+00
Bromine	0.02	1.327E-04
Calcium	0.25	2.217E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.04	3.262E-04
Cobalt	0.00	0.000E+00
Chromium	0.00	0.000E+00
Cesium	0.00	0.000E+00
Copper	0.02	1.327E-04
Iron	0.13	1.158E-03
Indium	0.08	6.879E-04
Potassium	0.02	2.071E-04
Magnesium	0.00	0.000E+00
Manganese	0.00	0.000E+00
Sodium	0.00	0.000E+00
Nickel	0.01	1.140E-04
Phosphorous	0.00	0.000E+00
Lead	0.01	9.828E-05
Rubidium	0.00	3.832E-05
Sulfur	1.74	1.511E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.00	0.000E+00
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	0.05	4.158E-04
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	203.26	4.359E-01
Organic Carbon	1041.70	2.234E+00

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	38
Fuel:	Dry Lump Coal	Date:	8/15/2011		

Filter Information:

T1 ID #:	A7797280
T1 Flow Rate [mL/min]:	170.9
T1 Sample Volume [dsft^3]:	2.18
Q1 ID #:	A768265H
Q1 Flow Rate [mL/min]:	990.81
Q1 Sample Volume [dsft^3]:	12.66

Run Information:

Test Duration [min]:	369
Tunnel Flow [dsft^3/min]:	515.7899
Barometric Pressure [in Hg]:	30.14
Temperature [°F]	82.773
Avg Delta H [in H2O]:	0.4588

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	578.00	8.191E+00
K^+	0.21	2.943E-03
Na^+	0.16	2.301E-03
NH_4^+	1.04	1.477E-02
NO_3	0.93	1.311E-02
SO_4	4.60	6.514E-02
Silver	0.00	0.000E+00
Aluminum	0.16	2.334E-03
Arsenic	0.00	0.000E+00
Barium	0.00	0.000E+00
Bromine	0.02	2.530E-04
Calcium	0.09	1.255E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.19	2.703E-03
Cobalt	0.00	1.443E-05
Chromium	0.01	8.336E-05
Cesium	0.00	0.000E+00
Copper	0.00	4.325E-05
Iron	0.05	7.195E-04
Indium	0.00	0.000E+00
Potassium	0.12	1.691E-03
Magnesium	0.00	0.000E+00
Manganese	0.00	0.000E+00
Sodium	0.00	0.000E+00
Nickel	0.00	0.000E+00
Phosphorous	0.00	0.000E+00
Lead	0.06	8.328E-04
Rubidium	0.00	1.601E-05
Sulfur	2.47	3.495E-02
Antimony	0.00	0.000E+00
Selenium	0.00	0.000E+00
Silicon	0.08	1.173E-03
Tin	0.00	0.000E+00
Strontium	0.00	0.000E+00
Titanium	0.00	1.604E-05
Vanadium	0.00	4.812E-05
Zinc	0.09	1.230E-03
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	69.56	1.700E-01
Organic Carbon	2238.03	5.470E+00

Appliance:	Coal Stove	Burn Rate:	Low, Cold Start	Run #:	39
Fuel:	Wet Stoker Coal	Date:	8/16/2011		

Filter Information:

T1 ID #:	A779725X
T1 Flow Rate [mL/min]:	198.37
T1 Sample Volume [dsft^3]:	*3.09*
Q1 ID #:	A768264G & A768263F
Q1 Flow Rate [mL/min]:	1583.7
Q1 Sample Volume [dsft^3]:	*24.67*

Run Information:

Test Duration [min]:	448
Tunnel Flow [dsft^3/min]:	522.0773
Barometric Pressure [in Hg]:	30.15
Temperature [°F]	80.853
Avg Delta H [in H2O]:	0.4557

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**1429.00**	**1.449E+01**
K^+	0.94	**9.488E-03**
Na^+	0.15	**1.508E-03**
NH_4^+	4.30	**4.358E-02**
NO_3	1.15	**1.163E-02**
SO_4	15.87	**1.609E-01**
Silver	0.00	**0.000E+00**
Aluminum	0.40	**4.040E-03**
Arsenic	0.02	**1.949E-04**
Barium	0.00	**0.000E+00**
Bromine	0.05	**5.387E-04**
Calcium	0.20	**1.983E-03**
Cadmium	0.00	**0.000E+00**
Cerium	0.00	**0.000E+00**
Chlorine	0.77	**7.769E-03**
Cobalt	0.04	**4.441E-04**
Chromium	0.00	**0.000E+00**
Cesium	0.00	**0.000E+00**
Copper	0.00	**0.000E+00**
Iron	0.14	**1.382E-03**
Indium	0.00	**0.000E+00**
Potassium	2.18	**2.206E-02**
Magnesium	0.00	**0.000E+00**
Manganese	0.00	**0.000E+00**
Sodium	0.03	**3.432E-04**
Nickel	0.00	**0.000E+00**
Phosphorous	0.00	**0.000E+00**
Lead	0.06	**6.189E-04**
Rubidium	0.00	**1.146E-05**
Sulfur	11.58	**1.174E-01**
Antimony	0.00	**0.000E+00**
Selenium	0.02	**2.017E-04**
Silicon	0.00	**0.000E+00**
Tin	0.00	**0.000E+00**
Strontium	0.02	**1.834E-04**
Titanium	0.00	**0.000E+00**
Vanadium	0.01	**1.495E-04**
Zinc	0.60	**6.043E-03**
Zirconium	0.00	**0.000E+00**

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	1951.90	2.479E+00
Organic Carbon	6351.17	8.066E+00

Appliance:	Oil Burner	**Burn Rate:**	Single	**Run #:**	40
Fuel:	No 1 Fuel Oil	**Date:**	8/7/2011		

Filter Information:

T1 ID #:	A779724W
T1 Flow Rate [mL/min]:	195.29
T1 Sample Volume [dsft^3]:	*6.01*
Q1 ID #:	A768268K
Q1 Flow Rate [mL/min]:	1020.9
Q1 Sample Volume [dsft^3]:	*31.42*

Run Information:

Test Duration [min]:	885
Tunnel Flow [dsft^3/min]:	518.3042
Barometric Pressure [in Hg]:	30.18
Temperature [°F]	81.12
Avg Delta H [in H2O]:	0.4344

Teflon Sample:	Catch [µg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**60.00**	**3.104E-01**
K^+	0.16	8.367E-04
Na^+	0.16	8.286E-04
NH_4^+	4.22	2.183E-02
NO_3	0.73	3.769E-03
SO_4	11.48	5.941E-02
Silver	0.00	0.000E+00
Aluminum	0.21	1.110E-03
Arsenic	0.00	0.000E+00
Barium	0.00	0.000E+00
Bromine	0.00	2.514E-05
Calcium	0.29	1.480E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	0.01	6.440E-05
Cobalt	0.01	4.210E-05
Chromium	0.00	1.988E-05
Cesium	0.00	0.000E+00
Copper	0.03	1.368E-04
Iron	0.12	6.268E-04
Indium	0.14	7.015E-04
Potassium	0.05	2.633E-04
Magnesium	0.00	0.000E+00
Manganese	0.01	3.508E-05
Sodium	0.00	0.000E+00
Nickel	0.00	7.015E-06
Phosphorous	0.00	0.000E+00
Lead	0.00	0.000E+00
Rubidium	0.00	1.052E-05
Sulfur	3.92	2.026E-02
Antimony	0.03	1.754E-04
Selenium	0.00	0.000E+00
Silicon	0.06	3.343E-04
Tin	0.00	0.000E+00
Strontium	0.01	5.846E-05
Titanium	0.01	5.848E-05
Vanadium	0.00	0.000E+00
Zinc	0.01	3.566E-05
Zirconium	0.00	0.000E+00

Quartz Sample:	Catch [µg]:	Emission Rate [g/hr]
Elemental Carbon	6.51	6.440E-03
Organic Carbon	157.78	1.561E-01

Appliance:	EPA Stove	Burn Rate:	Low, Cold Start	Run #:	41
Fuel:	Birch	Date:	8/18/2011		

Filter Information:

T1 ID #:	A779721T
T1 Flow Rate [mL/min]:	202.47
T1 Sample Volume [dsft^3]:	2.04
Q1 ID #:	A768269L
Q1 Flow Rate [mL/min]:	1022.3
Q1 Sample Volume [dsft^3]:	10.32

Run Information:

Test Duration [min]:	288
Tunnel Flow [dsft^3/min]:	477.4781
Barometric Pressure [in Hg]:	30.145
Temperature [°F]	76.5744
Avg Delta H [in H2O]:	0.448

Teflon Sample:	Catch [μg]:	Emission Rate [g/hr]
Total $PM_{2.5}$	**489.00**	**6.857E+00**
K^+	2.80	3.925E-02
Na^+	0.19	2.603E-03
NH_4^+	1.44	2.015E-02
NO_3	1.70	2.385E-02
SO_4	6.96	9.757E-02
Silver	0.00	0.000E+00
Aluminum	0.00	0.000E+00
Arsenic	0.01	1.791E-04
Barium	0.00	0.000E+00
Bromine	0.03	4.231E-04
Calcium	0.37	5.189E-03
Cadmium	0.00	0.000E+00
Cerium	0.00	0.000E+00
Chlorine	1.81	2.532E-02
Cobalt	0.07	9.133E-04
Chromium	0.01	9.994E-05
Cesium	0.00	0.000E+00
Copper	0.04	5.644E-04
Iron	0.12	1.633E-03
Indium	0.00	0.000E+00
Potassium	3.51	4.926E-02
Magnesium	0.00	0.000E+00
Manganese	0.00	1.903E-05
Sodium	0.00	0.000E+00
Nickel	0.00	3.646E-05
Phosphorous	0.00	0.000E+00
Lead	0.00	0.000E+00
Rubidium	0.00	0.000E+00
Sulfur	3.52	4.939E-02
Antimony	0.00	0.000E+00
Selenium	0.01	9.668E-05
Silicon	0.05	7.648E-04
Tin	0.00	0.000E+00
Strontium	0.01	1.585E-04
Titanium	0.00	0.000E+00
Vanadium	0.00	0.000E+00
Zinc	0.91	1.282E-02
Zirconium	0.05	6.339E-04

Quartz Sample:		Emission Rate [g/hr]
Elemental Carbon	111.51	3.097E-01
Organic Carbon	1016.51	2.823E+00

Measurement of Space-Heating Emissions

Appendix B

Analytical Laboratory Reports

Fuel Analysis: Pellets

Twin Ports Testing Inc.

1301 N. 3rd St. • Superior WI 54880 • 715-392-7114 • 800-373-2562 • F 715-392-7163 • www.twinportstesting.com

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Date Received: Apr 13, 2011
Date Tested: Apr 18, 2011
PO Number: OTL-11-029

Attn: Lyrik Pitzman

Sample Log No: 11C1231
Sample Designation: P1 Pellet Sample 1 4-7-11

	METHOD	UNITS	MOISTURE & ASH FREE	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM D3173	wt. %			7.09
Ash	ASTM D3174	wt. %		0.83	0.77
Volatile Matter	ASTM D3175	wt. %		------	------
Fixed Carbon By Difference	ASTM D3175	wt. %		------	------
Sulfur	ASTM D4239	wt. %		0.008	0.007
Gross Heating Value	ASTM D5865	BTU/lb	8664	8592	7984
Carbon	ASTM D5373	wt. %		50.36	46.79
Hydrogen	ASTM D5373	wt. %		6.41	5.96
Nitrogen	ASTM D5373	wt. %		< 0.14	< 0.13
Oxygen	ASTM D3176	wt. %		> 42.26	> 39.26
Chlorine	ASTM D6721	ug/g			
Fluorine	ASTM D3761	ug/g			
Mercury	ASTM D6722	ug/g			
Sodium Oxide in Ash	ASTM D3682	wt. %			
Hardgrove Grindability Index	ASTM D409	wt. /index			

Additional:

Prepared By: [signature]

Date: 4/18/11

B1

Fuel Analysis: Birch Cordwood

Twin Ports Testing Inc.

1301 N. 3rd St. • Superior WI 54880 • 715-392-7114 • 800-373-2562 • F 715-392-7163 • www.twinportstesting.com

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Date Received: Apr 13, 2011
Date Tested: Apr 18, 2011
PO Number: OTL-11-029

Attn: Lyrik Pitzman

Sample Log No: 11C1232
Sample Designation: W1 Birch Cordwood 4-7-11

	METHOD	UNITS	MOISTURE & ASH FREE	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM D3173	wt. %			12.51
Ash	ASTM D3174	wt. %		0.73	0.64
Volatile Matter	ASTM D3175	wt. %		------	------
Fixed Carbon By Difference	ASTM D3175	wt. %		------	------
Sulfur	ASTM D4239	wt. %		0.080	0.070
Gross Heating Value	ASTM D5865	BTU/lb	8653	8590	7515
Carbon	ASTM D5373	wt. %		49.55	43.35
Hydrogen	ASTM D5373	wt. %		6.41	5.61
Nitrogen	ASTM D5373	wt. %		< 0.18	< 0.16
Oxygen	ASTM D3176	wt. %		> 43.05	> 37.66
Chlorine	ASTM D6721	ug/g			
Fluorine	ASTM D3761	ug/g			
Mercury	ASTM D6722	ug/g			
Sodium Oxide in Ash	ASTM D3682	wt. %			
Hardgrove Grindability Index	ASTM D409	wt. /index			

Additional:

Prepared By: [signature] Date: 4/18/11

B2

Fuel Analysis: Spruce Cordwood

Twin Ports Testing Inc.

1301 N. 3rd St. • Superior WI 54880 • 715-392-7114 • 800-373-2562 • F 715-392-7163 • www.twinportstesting.com

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Date Received: Apr 13, 2011
Date Tested: Apr 18, 2011
PO Number: OTL-11-029

Attn: Lyrik Pitzman

Sample Log No: 11C1233
Sample Designation: W2 Spruce Cordwood 4-7-11

	METHOD	UNITS	MOISTURE & ASH FREE	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM D3173	wt. %			15.01
Ash	ASTM D3174	wt. %		0.63	0.53
Volatile Matter	ASTM D3175	wt. %		------	------
Fixed Carbon By Difference	ASTM D3175	wt. %		------	------
Sulfur	ASTM D4239	wt. %		0.010	0.009
Gross Heating Value	ASTM D5865	BTU/lb	8804	8749	7435
Carbon	ASTM D5373	wt. %		50.30	42.75
Hydrogen	ASTM D5373	wt. %		6.40	5.44
Nitrogen	ASTM D5373	wt. %		< 0.11	< 0.09
Oxygen	ASTM D3176	wt. %		> 42.56	> 36.17
Chlorine	ASTM D6721	ug/g			
Fluorine	ASTM D3761	ug/g			
Mercury	ASTM D6722	ug/g			
Sodium Oxide in Ash	ASTM D3682	wt. %			
Hardgrove Grindability Index	ASTM D409	wt. /index			

Additional:

Prepared By: [signature]

Date: 4/18/11

B3

Fuel Analysis: Lump Coal

Twin Ports Testing Inc.

1301 N. 3rd St. • Superior WI 54880 • 715-392-7114 • 800-373-2562 • F 715-392-7163 • www.twinportstesting.com

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Date Received: Apr 13, 2011
Date Tested: Apr 18, 2011
PO Number: OTL-11-029

Attn: Lyrik Pitzman

Sample Log No: 11C1234
Sample Designation: C1 Lump Coal 4-8-11

	METHOD	UNITS	MOISTURE & ASH FREE	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM D3173	wt. %			25.66
Ash	ASTM D3174	wt. %		6.12	4.55
Volatile Matter	ASTM D3175	wt. %		------	------
Fixed Carbon By Difference	ASTM D3175	wt. %		------	------
Sulfur	ASTM D4239	wt. %		0.086	0.064
Gross Heating Value	ASTM D5865	BTU/lb	11900	11171	8305
Carbon	ASTM D5373	wt. %		65.00	48.32
Hydrogen	ASTM D5373	wt. %		4.72	3.51
Nitrogen	ASTM D5373	wt. %		0.65	0.48
Oxygen	ASTM D3176	wt. %		23.42	17.41
Chlorine	ASTM D6721	ug/g			
Fluorine	ASTM D3761	ug/g			
Mercury	ASTM D6722	ug/g			
Sodium Oxide in Ash	ASTM D3682	wt. %			
Hardgrove Grindability Index	ASTM D409	wt. /index			

Additional:

Prepared By: [signature]

Date: 4/18/11

B4

Fuel Analysis: Stoker Coal

Twin Ports Testing Inc.

1301 N. 3rd St. • Superior WI 54880 • 715-392-7114 • 800-373-2562 • F 715-392-7163 • www.twinportstesting.com

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Date Received: Apr 13, 2011
Date Tested: Apr 18, 2011
PO Number: OTL-11-029

Attn: Lyrik Pitzman

Sample Log No: 11C1235
Sample Designation: C2 Stoker Coal 4-8-11

	METHOD	UNITS	MOISTURE & ASH FREE	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM D3173	wt. %			25.94
Ash	ASTM D3174	wt. %		5.20	3.85
Volatile Matter	ASTM D3175	wt. %		------	------
Fixed Carbon By Difference	ASTM D3175	wt. %		------	------
Sulfur	ASTM D4239	wt. %		0.101	0.075
Gross Heating Value	ASTM D5865	BTU/lb	12253	11617	8602
Carbon	ASTM D5373	wt. %		66.75	49.44
Hydrogen	ASTM D5373	wt. %		4.95	3.67
Nitrogen	ASTM D5373	wt. %		0.72	0.53
Oxygen	ASTM D3176	wt. %		22.28	16.50
Chlorine	ASTM D6721	ug/g			
Fluorine	ASTM D3761	ug/g			
Mercury	ASTM D6722	ug/g			
Sodium Oxide in Ash	ASTM D3682	wt. %			
Hardgrove Grindability Index	ASTM D409	wt. /index			

Additional:

Prepared By: [signature]

Date: 4/18/11

Fuel Analysis: Ultimate and Proximate Analyses of Oil #1, Oil #2, and Waste Oil

Test Summary Report
December 13, 2011

Omni Test Laboratories

		No. 1 Heating Oil	No. 2 Heating Oil	Waste Oil
	Lab ID	3173	3174	3175
ASTM D240 Net Heat of Combustion (Lower Heating Value)				
	BTU/lb	18483	18397	18024
	MJ/Kg	42.992	42.791	41.924
	Cal/g	10268	10220	10013
ASTM D240 Gross Heat of Combustion (Higher Heating Value)				
	BTU/lb	19721	19613	19237
	MJ/Kg	45.872	45.619	44.746
	Cal/g	10956	10896	10687
ASTM D482 Ash Content				
	wt%	<0.001	<0.001	0.88
ASTM D2622 Modified Chlorine Content				
Chlorine	ppm	<10	<10	8243.9
ASTM D5291 Carbon/Hydrogen Content				
Carbon	wt%	86.21	86.28	84.14
Hydrogen	wt%	13.57	13.33	13.3
ASTM D5291 Nitrogen Content				
Nitrogen	wt%	0.451	0.029	0.266
ASTM D6304 Water Content				
Water	ppm	86	58	398
Oxygen Content by Difference				
Oxygen	wt%	<1	<1	<1

Fuel Analysis: Elemental Analysis of Oil #1, Oil #2, and Waste Oil

Test Summary Report
December 13, 2011

Omni Test Laboratories

		No. 1 Heating Oil	No. 2 Heating Oil	Waste Oil
	Lab ID	3173	3174	3175
ASTM D5185 Elemental Analysis by ICP				
Aluminum	ppm	<1	<1	8
Barium	ppm	<1	<1	1
Boron	ppm	<1	<1	164
Calcium	ppm	<1	<1	1467
Chromium	Ppm	<1	<1	2
Copper	ppm	<1	<1	34
Iron	ppm	<1	<1	52
Lead	ppm	<1	<1	17
Magnesium	ppm	<1	<1	205
Molybdenum	ppm	<1	<1	82
Phosphorus	ppm	<1	<1	847
Sulfur	ppm	896	2566	3020
Silicon	ppm	<1	<1	14
Sodium	ppm	<5	<5	412
Zinc	ppm	<1	<1	974
Potassium	ppm	<5	<5	314
Titanium	ppm	<1	<1	44

Antimony, Manganese, Nickel, Silver, Tin, Strontium, Vanadium, Cadmium <1 ppm

Ash Analysis: Ultimate Analysis, All Fuels

Columbia Analytical Services

September 22, 2011

Client: OMNI-Test Laboratories, Inc.
13327 NE Airport Way
P.O. Box 301367
Portland, OR 97230

Attn: Sebastian Button

Project: FNSB Ash

Date Received: August 12, 2011

Certificate of Analysis

Sample ID:	Sample Date and Time:	Lab #:	Moisture, Total D3173 Moist. Free wt%	Carbon Moist. Free wt%	Hydrogen D5373 Moist. Free wt%	Nitrogen Moist. Free wt%	Oxygen D5373 mod Moist. Free wt%	Sulfur D4239 Moist. Free wt%	Ash D482 Moist. Free wt%
Birch Ash	8/8/11	T1101099-001	1.87	61.81	0.85	0.58	10.20	<0.005	28.66
Coal Ash	8/8/11	T1101099-002	0.29	1.49	0.46	0.08	6.07	1.17	96.60
Pellet Ash	8/8/11	T1101099-003	4.14	72.99	1.33	0.57	14.03	0.01	9.90
Spruce Ash	8/8/11	T1101099-004	2.57	68.26	1.44	0.45	11.70	<0.005	18.04

3860 S. Palo Verde Rd.
Suite 302
Tucson, AZ 85714
520.623.3381

Page 1 of 3

Rpt-T1101099 OMNI FNSB Ash Button, 9/22/2011

Ash Analysis: pH, All Fuels

Columbia Analytical Services

September 22, 2011

Client: OMNI-Test Laboratories, Inc.
13327 NE Airport Way
P.O. Box 301367
Portland, OR 97230

Attn: Sebastian Button

Project: FNSB Ash **Date Received:** August 12, 2011

Certificate of Analysis

Sample ID:	Sample Date and Time:	Lab #:		pH D9045					
Birch Ash	8/8/11	T1101099-001		11.66					
Coal Ash	8/8/11	T1101099-002		11.91					
Pellet Ash	8/8/11	T1101099-003		8.96					
Spruce Ash	8/8/11	T1101099-004		11.54					

Notes:

W.H. Cerda
Wendy H. Cerda, Project Chemist

3860 S. Palo Verde Rd.
Suite 302
Tucson, AZ 85714
520.623.3381

Rpt-T1101099 OMNI FNSB Ash Button, 9/22/2011

Ash Analysis: Total Metals, All Fuels

Columbia Analytical Services

September 22, 2011

Client: OMNI-Test Laboratories, Inc.
13327 NE Airport Way
P.O. Box 301367
Portland, OR 97230
Attn: Sebastian Button
Project: FNSB Ash

Date Received: *August 12, 2011*

Certificate of Analysis

Total Metals by ICP-OES	*ID*	Birch Ash		Coal Ash		Pellet Ash		Spruce Ash		
	Units	T1101099-001		T1101099-002		T1101099-003		T1101099-004		
Aluminum	wt %		0.06		7.96		0.11		0.14	
Antimony	wt %	<	0.20	<	0.20	<	0.20	<	0.20	
Arsenic	wt %		0.06		0.04		0.03		0.02	
Barium	wt %		0.24		0.55		0.06		0.09	
Beryllium	wt %	<	0.001	<	0.001	<	0.001	<	0.001	
Cadmium	wt %	<	0.001		0.003		0.002		0.002	
Calcium	wt %		8.31		21.80		4.03		7.02	
Chromium	wt %	<	0.01		0.01	<	0.01	<	0.01	
Cobalt	wt %		0.02		0.01		0.01		0.01	
Copper	wt %		0.01		0.02	<	0.01	<	0.01	
Iron	wt %		0.07		8.06		0.08		0.18	
Lead	wt %	<	0.02	<	0.02	<	0.02	<	0.02	
Lithium	wt %	<	0.01	<	0.01	<	0.01	<	0.01	
Magnesium	wt %		1.17		1.93		0.37		0.42	
Manganese	wt %		0.51		0.11		0.11		0.11	
Molybdenum	wt %	<	0.01	<	0.01		0.02	<	0.01	
Nickel	wt %	<	0.01	<	0.01	<	0.01	<	0.01	
Phosphorus	wt %		0.89		0.10		0.12	<	0.05	
Potassium	wt %		5.07		0.71		1.76		2.65	
Selenium	wt %	<	0.05	<	0.05	<	0.05	<	0.05	
Silicon	wt %		1.62		11.97		0.58		0.23	
Silver	wt %	<	0.01	<	0.01	<	0.01	<	0.01	
Sodium	wt %	<	0.10		0.25	<	0.10	<	0.10	
Strontium	wt %		0.05		0.19		0.02		0.03	
Tin	wt %		0.03		0.02		0.02		0.01	
Titanium	wt %	<	0.01		0.38	<	0.01	<	0.01	
Vanadium	wt %	<	0.01		0.02	<	0.01	<	0.01	
Zinc	wt %		0.14	<	0.05	<	0.05	<	0.05	
Zirconium	wt %	<	0.01		0.02	<	0.01	<	0.01	

Note: *Values reported on an as received basis.*
Approximately 50 mg of sample was digested with HNO3, HF, and HCl brought to50.0 mL with DI water and analyzed by ICP-OES.

W.H. Cerda
Wendy H. Cerda, Project Chemist

3860 S. Palo Verde Rd.
Suite 302
Tucson, AZ 85714
520.623.3381

Page 3 of 3

Rpt-T1101099 OMNI FNSB Ash Button, 9/22/2011

Ammonia Analysis: Runs 1-3

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: OMNI Environmental Services, Incorporated
Project: Fairbanks North Star/477-S-01-1
Sample Matrix: Water

Service Request: K1102155
Date Collected: 3/8/2011
Date Received: 3/11/2011
Date Extracted: NA

Inorganic Parameters
Units: Total µg

	Analyte:	Volume of Bottle	Ammonia as Nitrogen
	Method	-	SM 4500-NH3 E
	Method Reporting Limit:	-	-
	Date Analyzed:	-	3/16/2011
Sample Name	**Lab Code**		
FNB 1-1	K1102155-001	250	101
FNB 1-2	K1102155-002	250	15
FNB 2-1	K1102155-003	250	39
FNB 2-2	K1102155-004	250	293
FNB 3-1	K1102155-005	250	152
FNB 3-2	K1102155-006	250	26
FNB - Blank	K1102155-007	250	<13
Method Blank	K1102155-MB	-	<13

3ADW/061694

K1102155wet.xls - 3_Tests 3/24/2011

Page No.:

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Ammonia Analysis: Runs 4-11

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	OMNI Environmental Services, Incorporated	**Service Request:**	K1102592
Project:	FNSB/477-S-01-1	**Date Collected:**	3/17/11 - 3/25/11
Sample Matrix:	Water	**Date Received:**	3/25/11
		Units:	mg/L
Analysis Method:	SM 4500-NH3 E	**Basis:**	NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 5-1	K1102592-001	4.31		0.050	1	NA	3/30/11 12:20	
FNB 5-2	K1102592-002	0.191		0.050	1	NA	3/30/11 12:20	
FNB 6-1	K1102592-003	1.75		0.050	1	NA	3/30/11 12:20	
FNB 6-2	K1102592-004	0.123		0.050	1	NA	3/30/11 12:20	
FNB 8-1	K1102592-005	24.5		0.050	1	NA	3/30/11 12:20	
FNB 8-2	K1102592-006	0.666		0.050	1	NA	3/30/11 12:20	
FNB 9-1	K1102592-007	10.8		0.050	1	NA	3/30/11 12:20	
FNB 9-2	K1102592-008	0.450		0.050	1	NA	3/30/11 12:20	
FNB 10-1	K1102592-009	6.13		0.050	1	NA	3/30/11 12:20	
FNB 10-2	K1102592-010	0.335		0.050	1	NA	3/30/11 12:20	
FNB 11-1	K1102592-011	12.0		0.050	1	NA	3/30/11 12:20	
FNB 11-2	K1102592-012	0.648		0.050	1	NA	3/30/11 12:20	
FNB Blank	K1102592-013	ND	U	0.050	1	NA	3/30/11 12:20	
Method Blank	K1102592-MB	ND	U	0.050	1	NA	3/30/11 12:20	

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Form 1A

SuperSet Reference: 11-0000173355 rev 00

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Ammonia Analysis: Runs 12-18

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: OMNI Environmental Services, Incorporated
Project: FNSB/477-S-01-1
Sample Matrix: Water

Service Request: K1103389
Date Collected: 3/30/11 - 4/15/11
Date Received: 4/19/11

Analysis Method: SM 4500-NH3 E

Units: mg/L
Basis: NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 12-1	K1103389-001	**1.05**		0.050	1	NA	4/20/11 12:00	
FNB 12-2	K1103389-002	**0.106**		0.050	1	NA	4/20/11 12:00	
FNB 13-1	K1103389-003	**6.84**		0.050	1	NA	4/20/11 12:00	
FNB 13-2	K1103389-004	**0.265**		0.050	1	NA	4/20/11 12:00	
FNB 14-1	K1103389-005	**3.36**		0.050	1	NA	4/20/11 12:00	
FNB 14-2	K1103389-006	**0.230**		0.050	1	NA	4/20/11 12:00	
FNB 15-1	K1103389-007	**7.80**		0.050	1	NA	4/20/11 12:00	
FNB 15-2	K1103389-008	**0.414**		0.050	1	NA	4/20/11 12:00	
FNB 16-1	K1103389-009	**0.215**		0.050	1	NA	4/20/11 12:00	
FNB 16-2	K1103389-010	**0.094**		0.050	1	NA	4/20/11 12:00	
FNB 17-1	K1103389-011	**0.186**		0.050	1	NA	4/20/11 12:00	
FNB 17-2	K1103389-012	**0.156**		0.050	1	NA	4/20/11 12:00	
FNB 18-1	K1103389-013	**0.172**		0.050	1	NA	4/20/11 12:00	
FNB 18-2	K1103389-014	**0.092**		0.050	1	NA	4/20/11 12:00	
Method Blank	K1103389-MB1	ND	U	0.050	1	NA	4/20/11 12:00	
Method Blank	K1103389-MB2	ND	U	0.050	1	NA	4/20/11 12:00	

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Ammonia Analysis: Runs 19-23

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: OMNI Environmental Services, Incorporated
Project: FNSB/477-S-01-1
Sample Matrix: Water

Service Request: K1104492
Date Collected: 5/ 5/11 - 5/11/11
Date Received: 5/19/11

Units: mg/L
Basis: NA

Analysis Method: SM 4500-NH3 E

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 19-1	K1104492-001	**1.81**		0.050	1	NA	5/27/11 12:50	
FNB 19-2	K1104492-002	**0.262**		0.050	1	NA	5/27/11 12:50	
FNB 20-1	K1104492-003	**2.40**		0.050	1	NA	5/27/11 12:50	
FNB 20-2	K1104492-004	**0.245**		0.050	1	NA	5/27/11 12:50	
FNB 21-1	K1104492-005	**21.4**		0.050	1	NA	5/27/11 12:50	
FNB 21-2	K1104492-006	**0.645**		0.050	1	NA	5/27/11 12:50	
FNB 23-1	K1104492-007	**18.0**		0.050	1	NA	5/27/11 12:50	
FNB 23-2	K1104492-008	**5.57**		0.050	1	NA	5/27/11 12:50	
Method Blank	K1104492-MB	ND	U	0.050	1	NA	5/27/11 12:50	

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Ammonia Analysis: Runs 25-29

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: OMNI Environmental Services, Incorporated
Project: FNSB/477-5-01-1
Sample Matrix: Water

Service Request: K1105474
Date Collected: 5/27/11 - 6/ 7/11
Date Received: 6/17/11

Analysis Method: SM 4500-NH3 F

Units: mg/L
Basis: NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 25-1	K1105474-001	**5.14**		0.050	1	NA	6/21/11 09:30	
FNB 25-2	K1105474-002	**0.532**		0.050	1	NA	6/21/11 09:30	
FNB 26-1	K1105474-003	**36.7**		0.050	1	NA	6/21/11 09:30	
FNB 26-2	K1105474-004	**0.776**		0.050	1	NA	6/21/11 09:30	
FNB 27-1	K1105474-005	**48.8**		0.050	1	NA	6/21/11 09:30	
FNB 27-2	K1105474-006	**1.54**		0.050	1	NA	6/21/11 09:30	
FNB 28-1	K1105474-007	**1.50**		0.050	1	NA	6/21/11 09:30	
FNB 28-2	K1105474-008	**0.716**		0.050	1	NA	6/21/11 09:30	
FNB 29-1	K1105474-009	**0.286**		0.050	1	NA	6/21/11 09:30	
FNB 29-2	K1105474-010	**0.214**		0.050	1	NA	6/21/11 09:30	
Method Blank	K1105474-MB1	ND	U	0.050	1	NA	6/21/11 09:30	
Method Blank	K1105474-MB2	ND	U	0.050	1	NA	6/21/11 09:30	

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Form 1A

SuperSet Reference: 11-0000181094 rev 00

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Ammonia Analysis: Runs 30-33

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	OMNI Environmental Services, Incorporated	**Service Request:**	K1106544
Project:	FNSB/477-S-01-1	**Date Collected:**	6/30/11 - 7/ 8/11
Sample Matrix:	Water	**Date Received:**	7/19/11
		Units:	mg/L
Analysis Method:	SM 4500-NH3 E	**Basis:**	NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 30-1	K1106544-001	**8.28**		0.050	1	NA	7/27/11 10:55	
FNB 30-2	K1106544-002	**0.708**		0.050	1	NA	7/27/11 10:55	
FNB 31-1	K1106544-003	**26.7**		0.050	1	NA	7/27/11 10:55	
FNB 31-2	K1106544-004	**2.31**		0.050	1	NA	7/27/11 10:55	
FNB 32-1	K1106544-005	**18.0**		0.050	1	NA	7/27/11 10:55	
FNB 32-2	K1106544-006	**0.978**		0.050	1	NA	7/27/11 10:55	
FNB 33-1	K1106544-007	**49.6**		0.050	1	NA	7/27/11 10:55	
FNB 33-2	K1106544-008	**2.55**		0.050	1	NA	7/27/11 10:55	
Method Blank	K1106544-MB1	ND	U	0.050	1	NA	7/27/11 10:55	
Method Blank	K1106544-MB2	ND	U	0.050	1	NA	7/27/11 10:55	

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Ammonia Analysis: Runs 34-41

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: OMNI Environmental Services, Incorporated
Project: FNSB/477-S-01-1
Sample Matrix: Water

Service Request: K1107736
Date Collected: 7/27/11 - 8/18/11
Date Received: 8/19/11

Analysis Method: SM 4500-NH3 E

Units: mg/L
Basis: NA

Ammonia as Nitrogen

Sample Name	Lab Code	Result	Q	MRL	Dilution Factor	Date Extracted	Date Analyzed	Note
FNB 34-1	K1107736-001	**4.91**		0.050	1	NA	8/24/11 08:20	
FNB 34-2	K1107736-002	**0.389**		0.050	1	NA	8/24/11 08:20	
FNB 35-1	K1107736-003	**1.22**		0.050	1	NA	8/24/11 08:20	
FNB 35-2	K1107736-004	**0.119**		0.050	1	NA	8/24/11 08:20	
FNB 36-1	K1107736-005	**42.8**		0.050	1	NA	8/24/11 08:20	
FNB 36-2	K1107736-006	**14.6**		0.050	1	NA	8/24/11 08:20	
FNB 37-1	K1107736-007	**18.7**		0.050	1	NA	8/24/11 08:20	
FNB 37-2	K1107736-008	**1.05**		0.050	1	NA	8/24/11 08:20	
FNB 38-1	K1107736-009	**11.6**		0.050	1	NA	8/24/11 08:20	
FNB 38-2	K1107736-010	**0.274**		0.050	1	NA	8/24/11 08:20	
FNB 39-1	K1107736-011	**32.8**		0.050	1	NA	8/24/11 08:20	
FNB 39-2	K1107736-012	**1.65**		0.050	1	NA	8/24/11 08:20	
FNB 40-1	K1107736-013	**0.729**		0.050	1	NA	8/24/11 08:20	
FNB 40-2	K1107736-014	**0.424**		0.050	1	NA	8/24/11 08:20	
FNB 41-1	K1107736-015	**3.46**		0.050	1	NA	8/24/11 08:20	
FNB 41-2	K1107736-016	ND	U	0.050	1	NA	8/24/11 08:20	
Method Blank	K1107736-MB	ND	U	0.050	1	NA	8/24/11 08:20	

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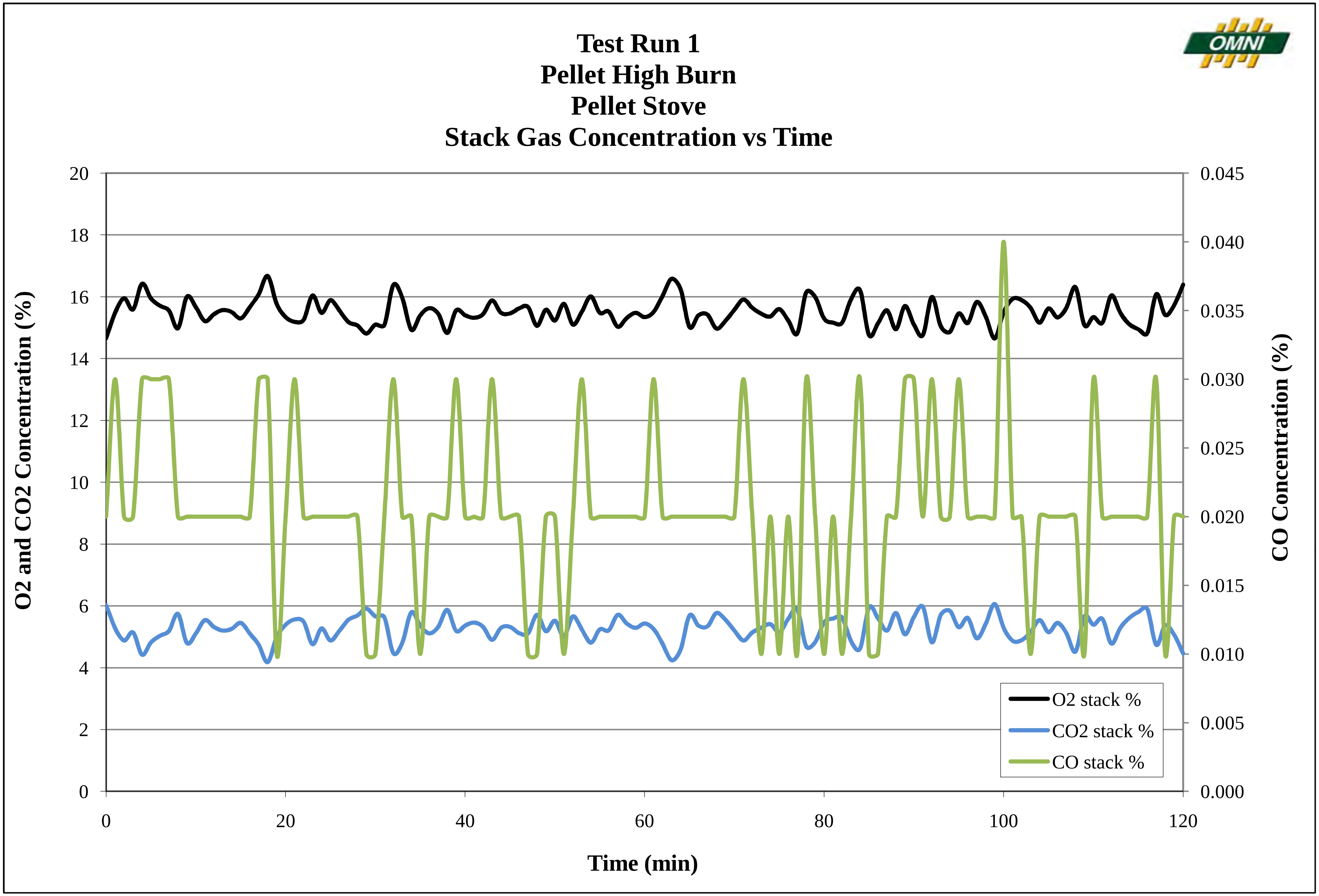
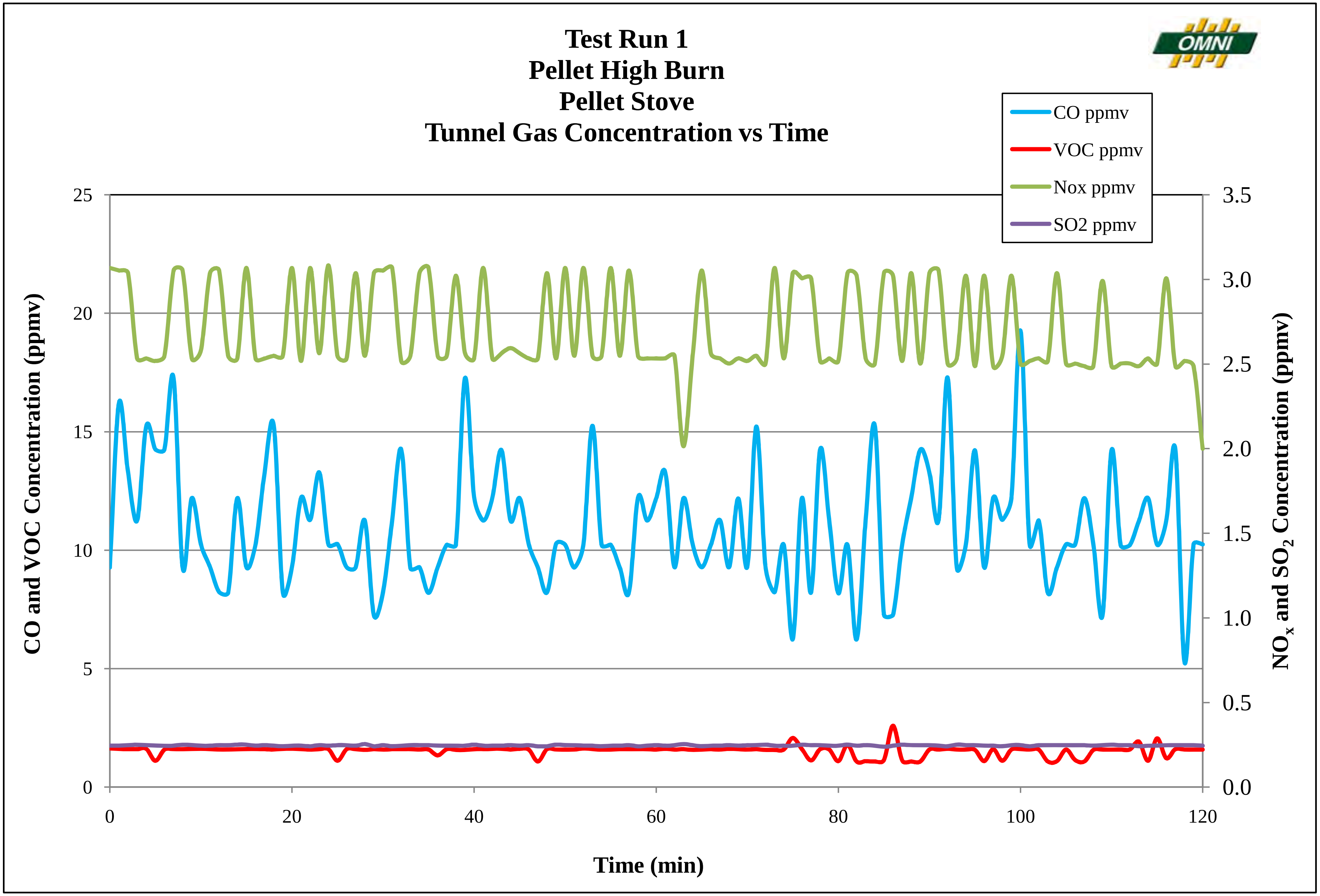
8

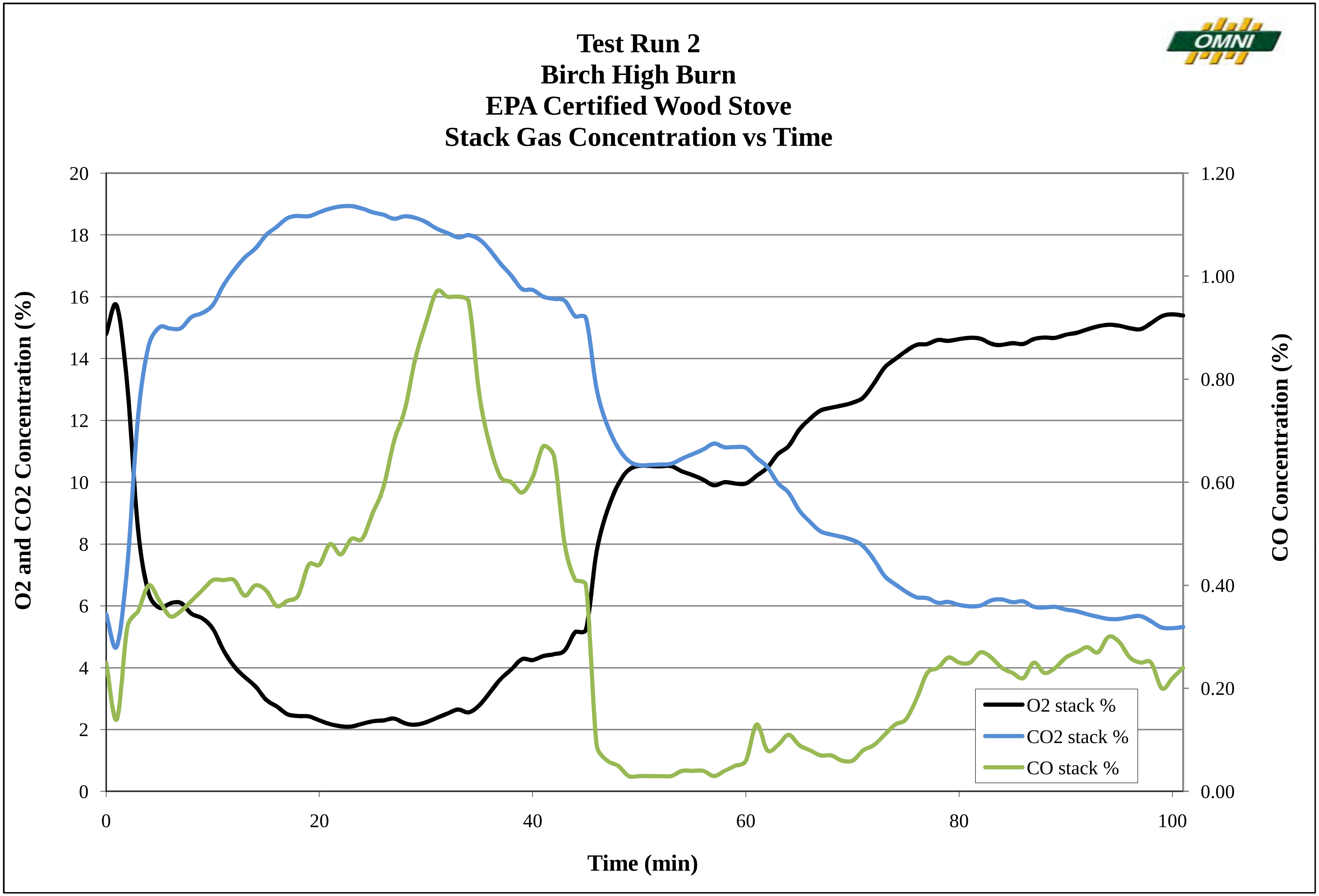
Measurement of Space-Heating Emissions

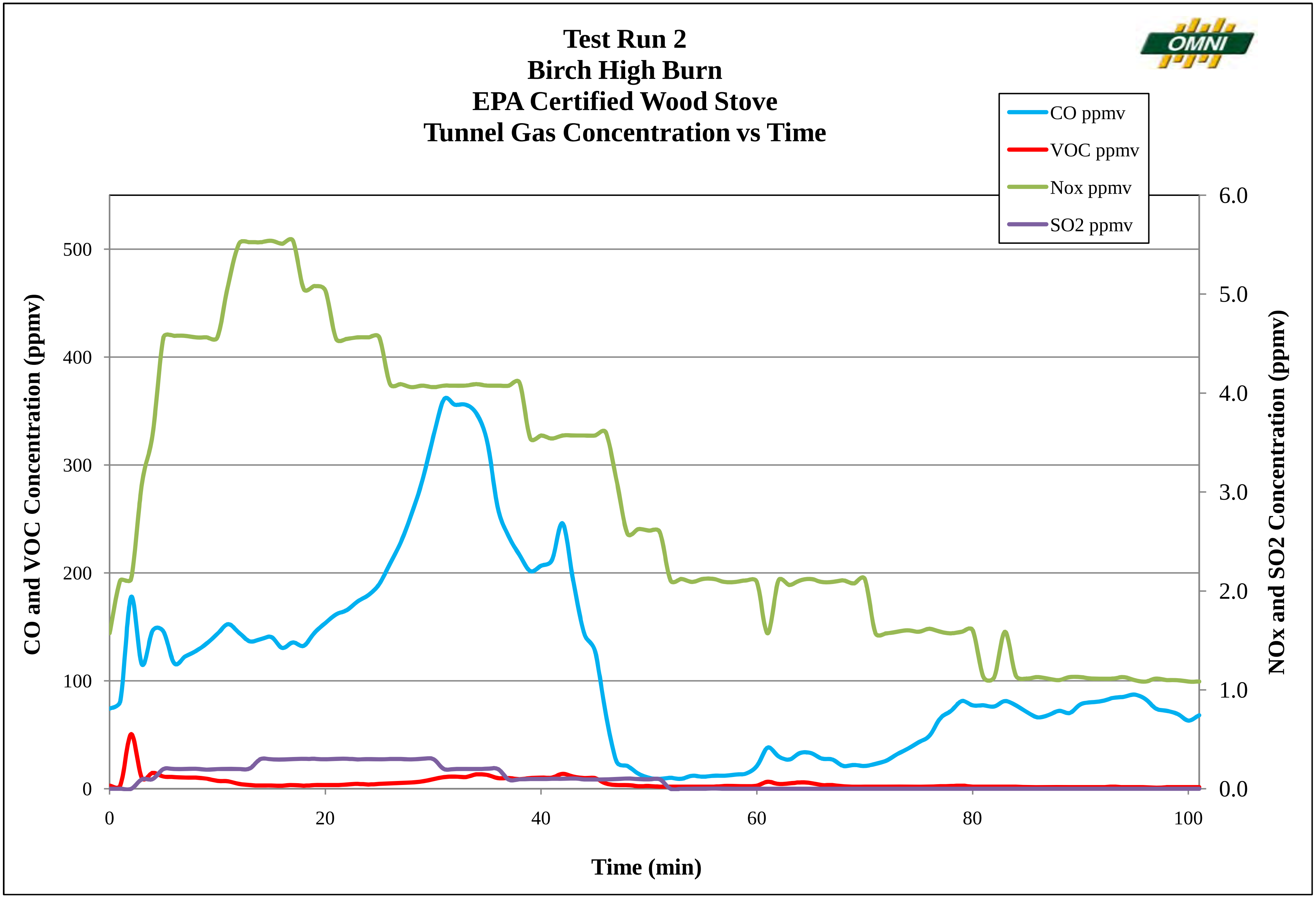
Appendix C

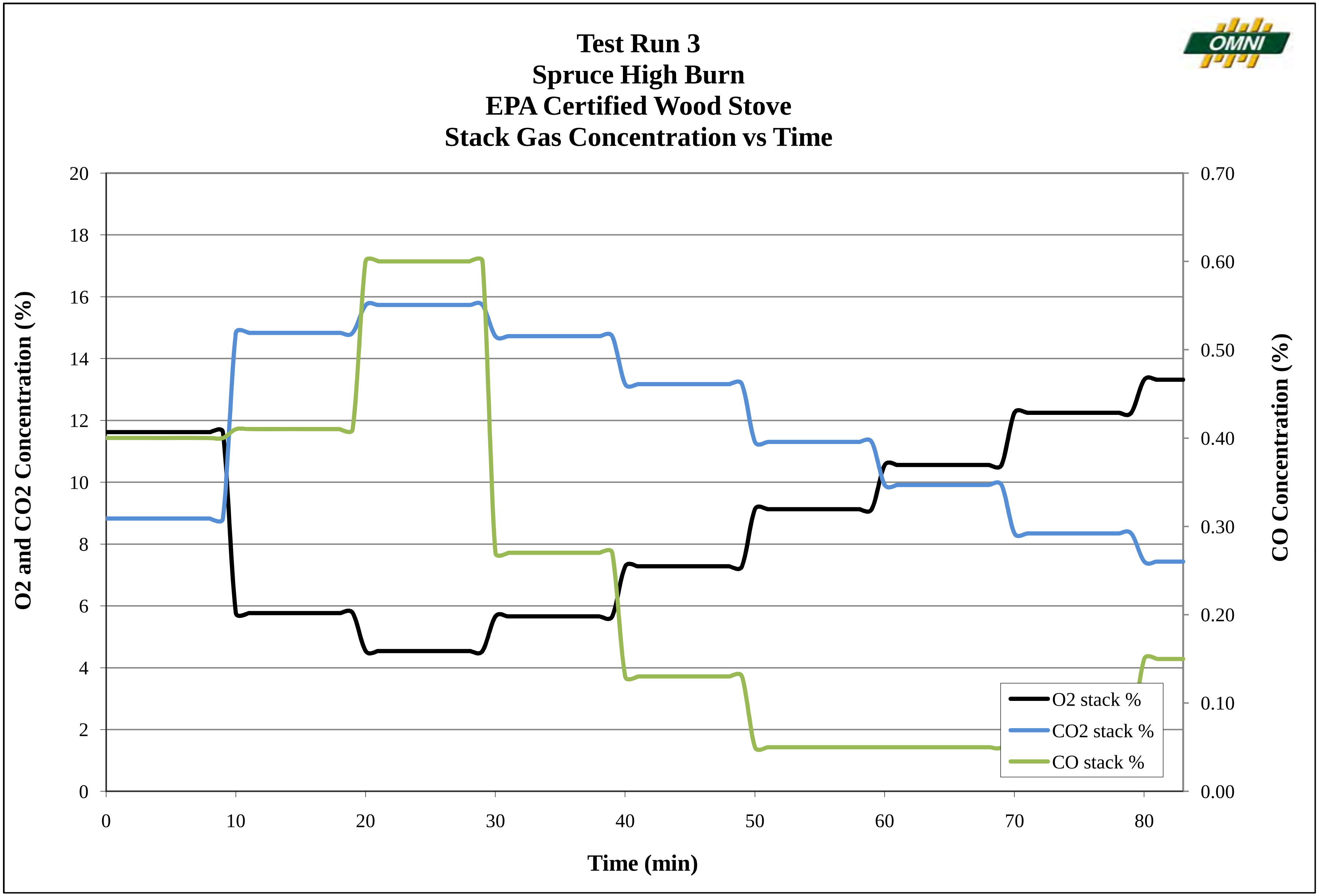
Real-Time Graphs

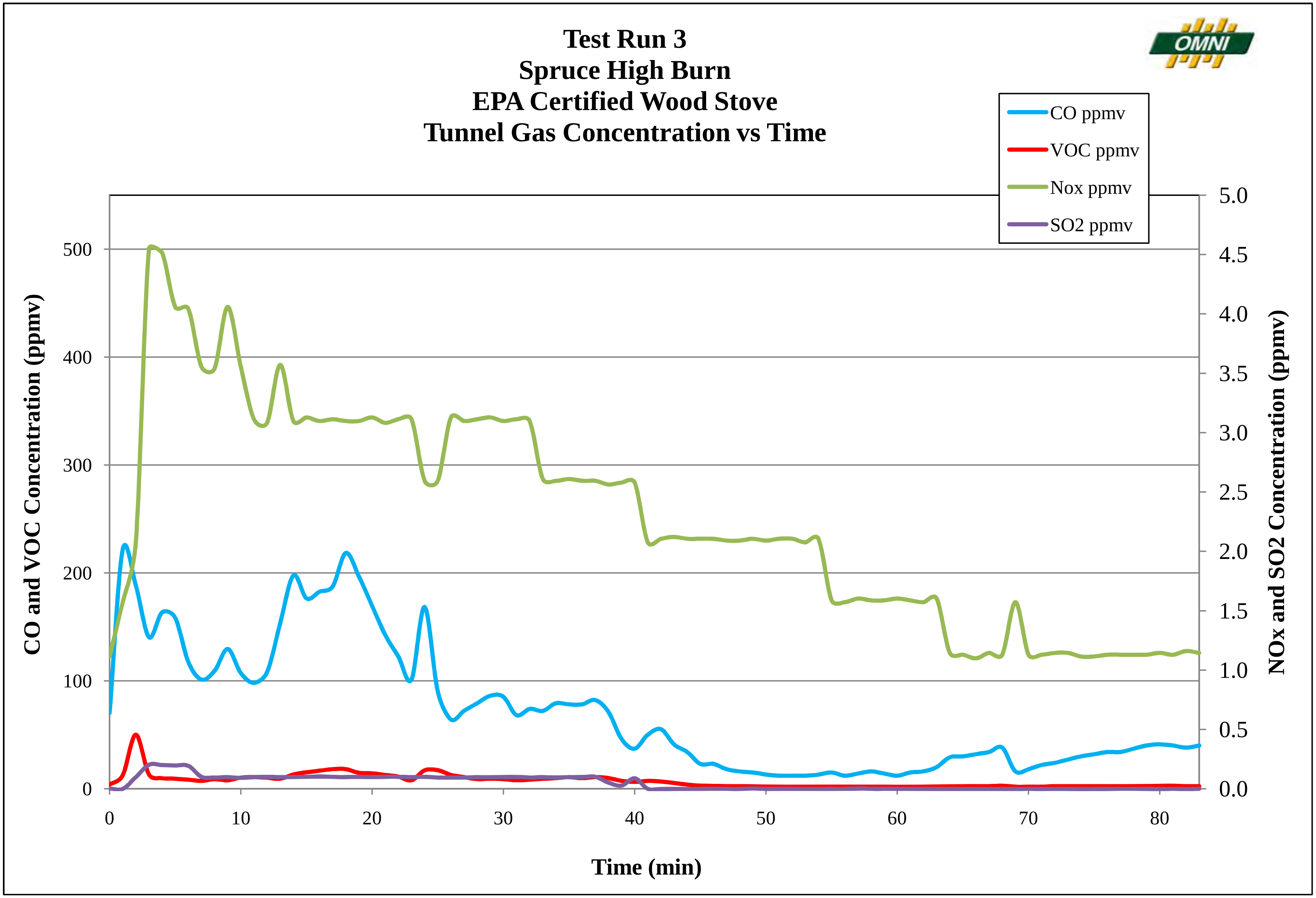

Test Run 1
Pellet High Burn
Pellet Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
20
18
16
14
12
10
8
6
4
2
0
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
120
Time (min)
O2 stack %
CO2 stack %
CO stack %

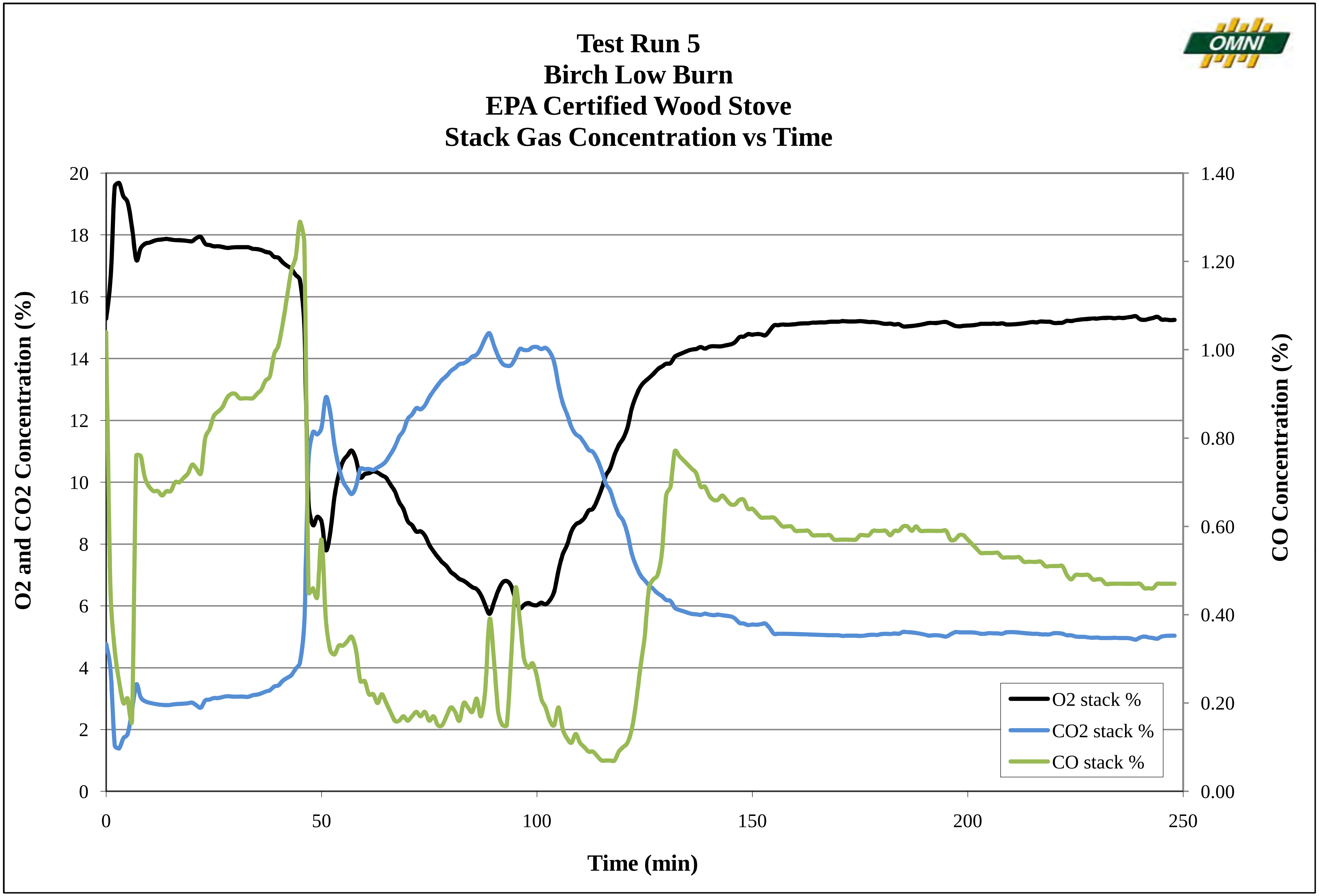

Test Run 1
Pellet High Burn
Pellet Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
20
40
60
80
100
120

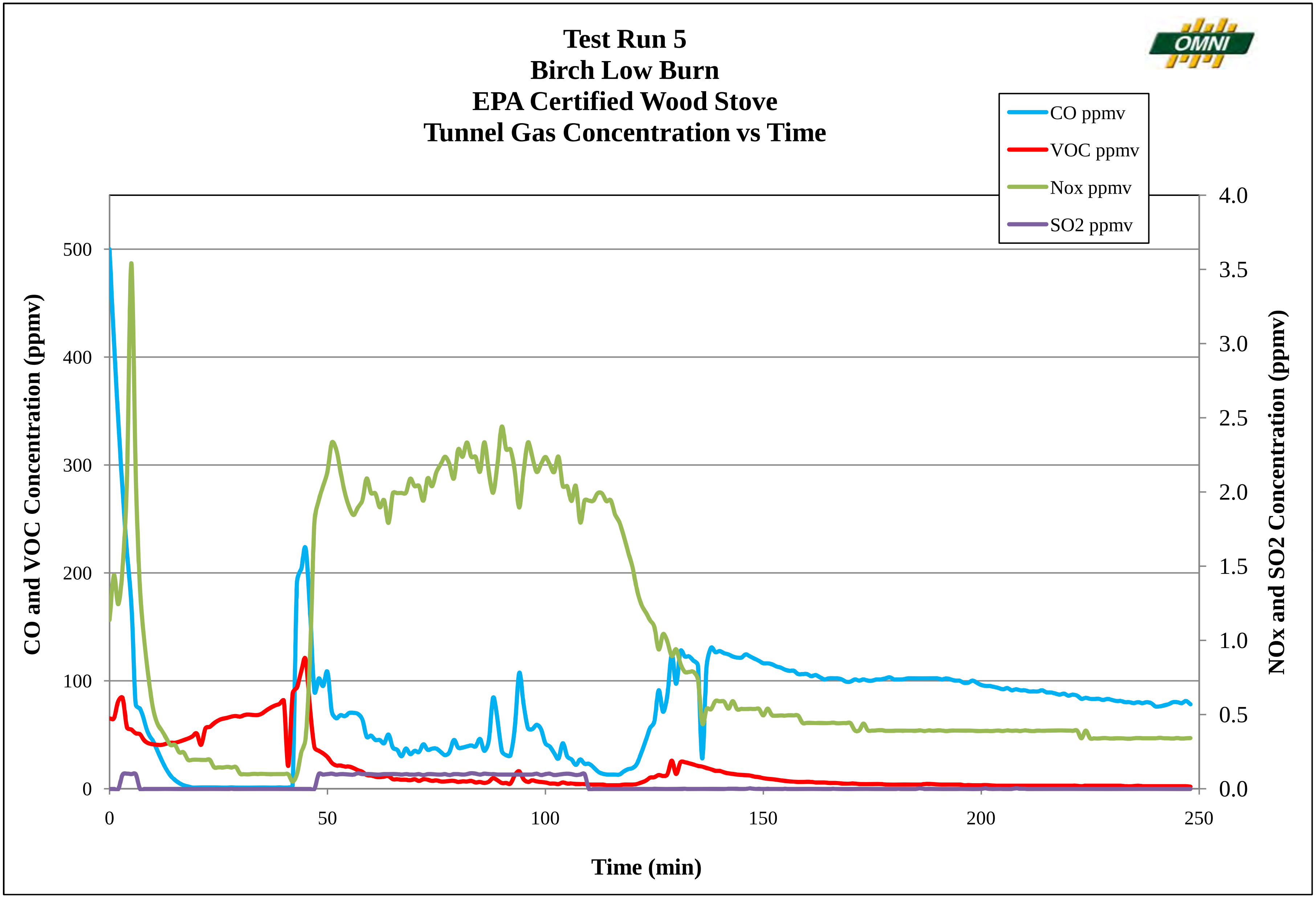

Test Run 2
Birch High Burn
EPA Certified Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0
20
40
60
80
100

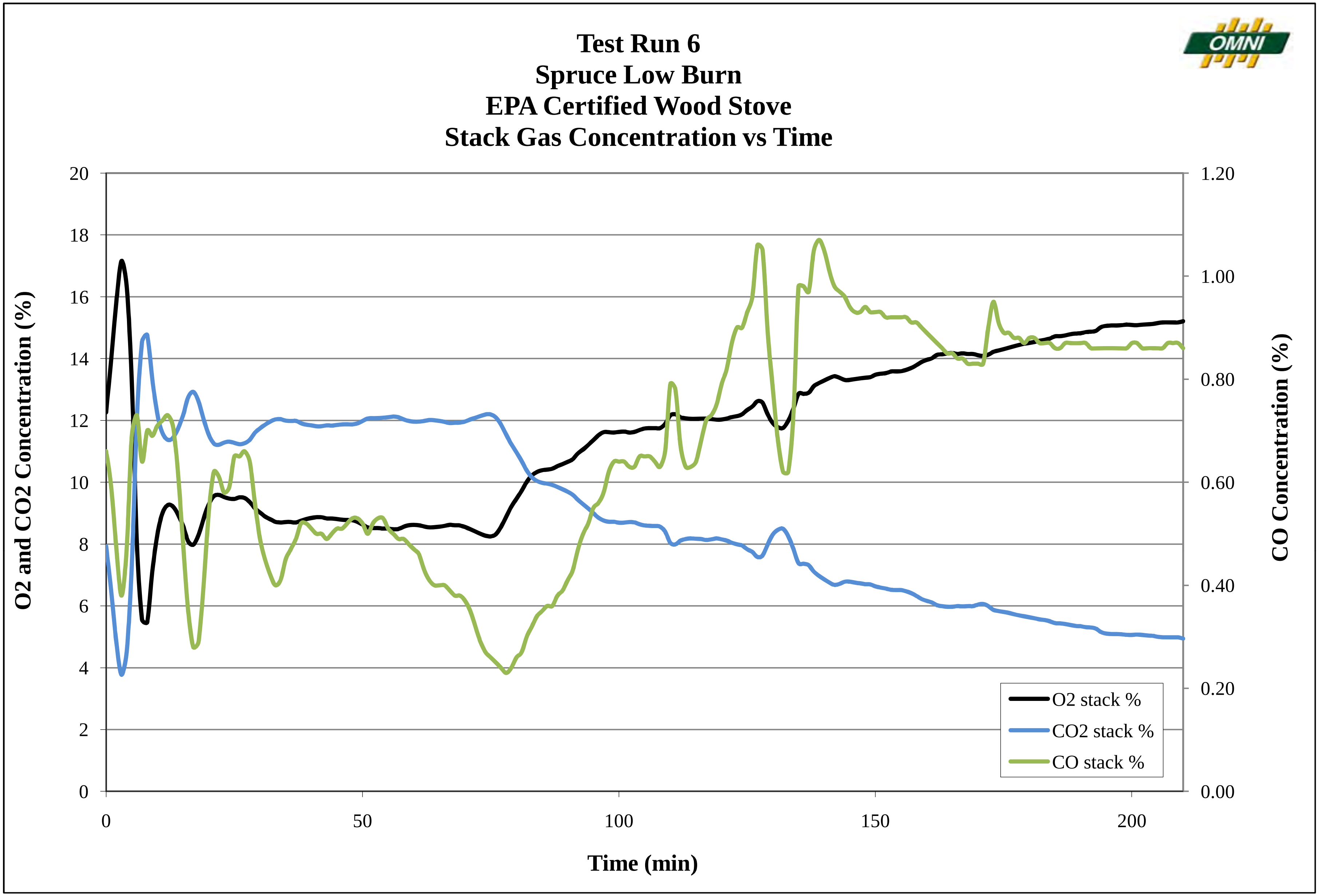

Test Run 2
Birch High Burn
EPA Certified Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0
20
40
60
80
100
Time (min)

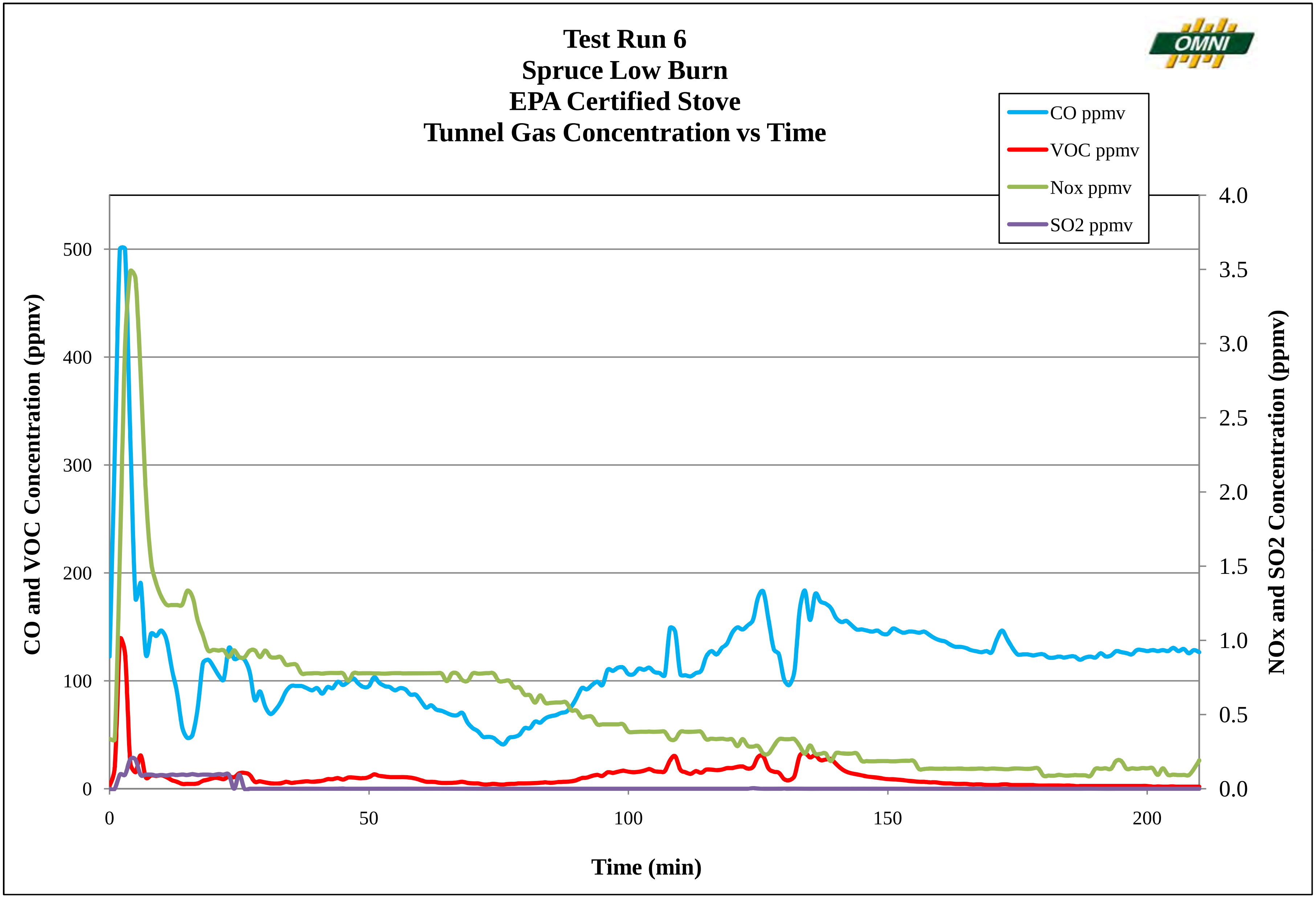

Test Run 3
Spruce High Burn
EPA Certified Wood Stove
Stack Gas Concentration vs Time
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0
10
20
30
40
50
60
70
80

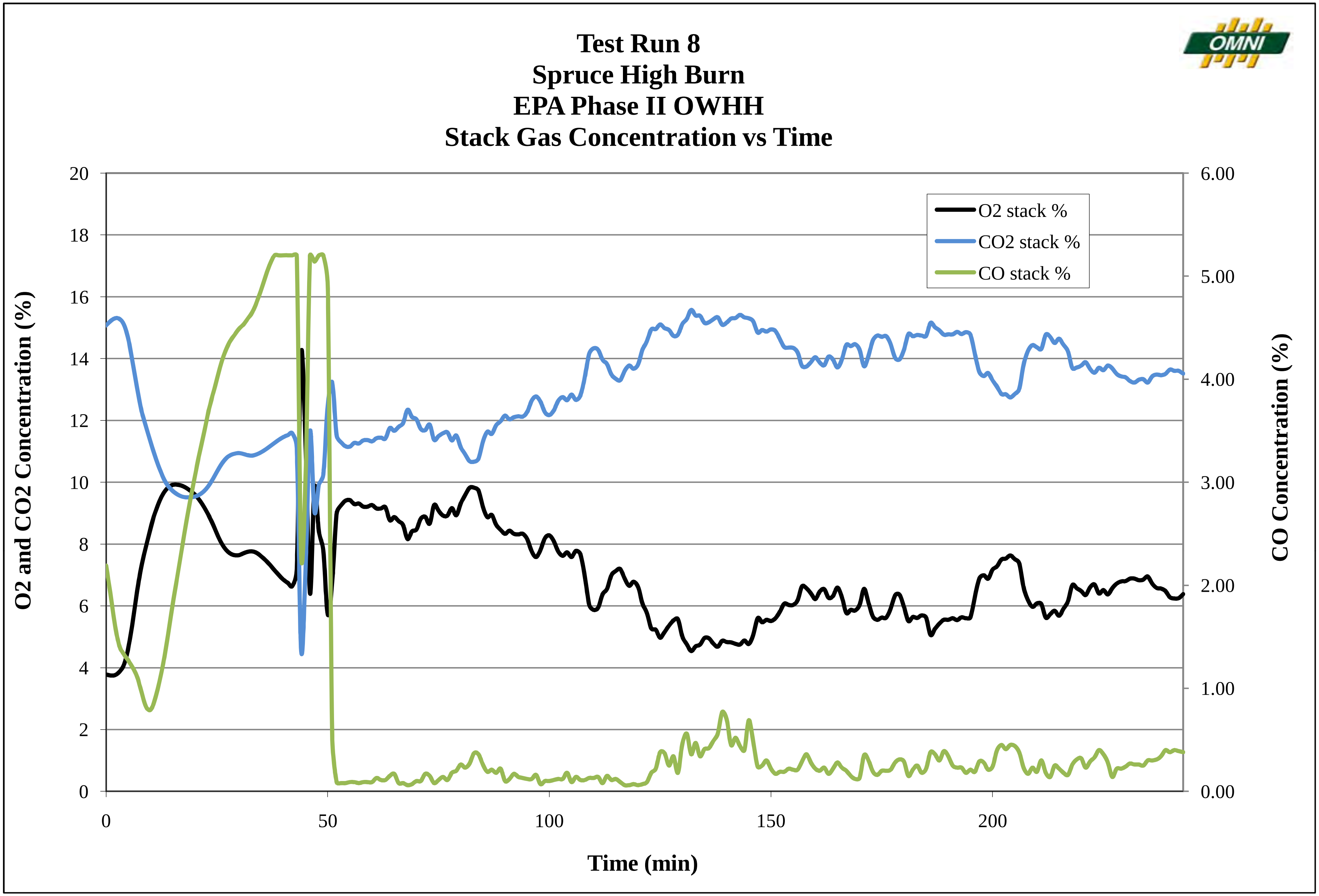

Test Run 3
Spruce High Burn
EPA Certified Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
10
20
30
40
50
60
70
80
Time (min)

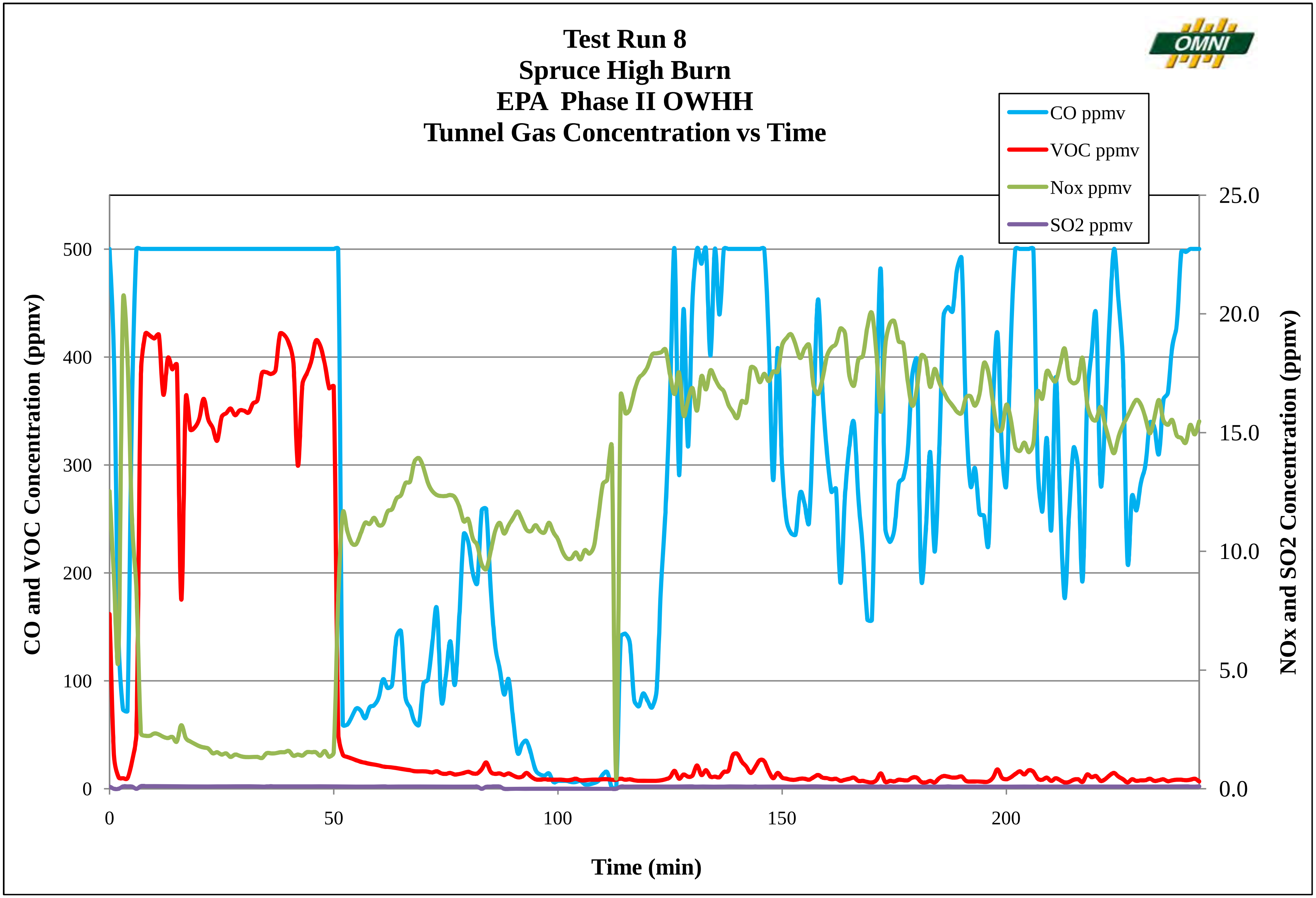

Test Run 5
Birch Low Burn
EPA Certified Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
20
18
16
14
12
10
8
6
4
2
0
CO Concentration (%)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
50
100
150
200
250
Time (min)
O2 stack %
CO2 stack %
CO stack %

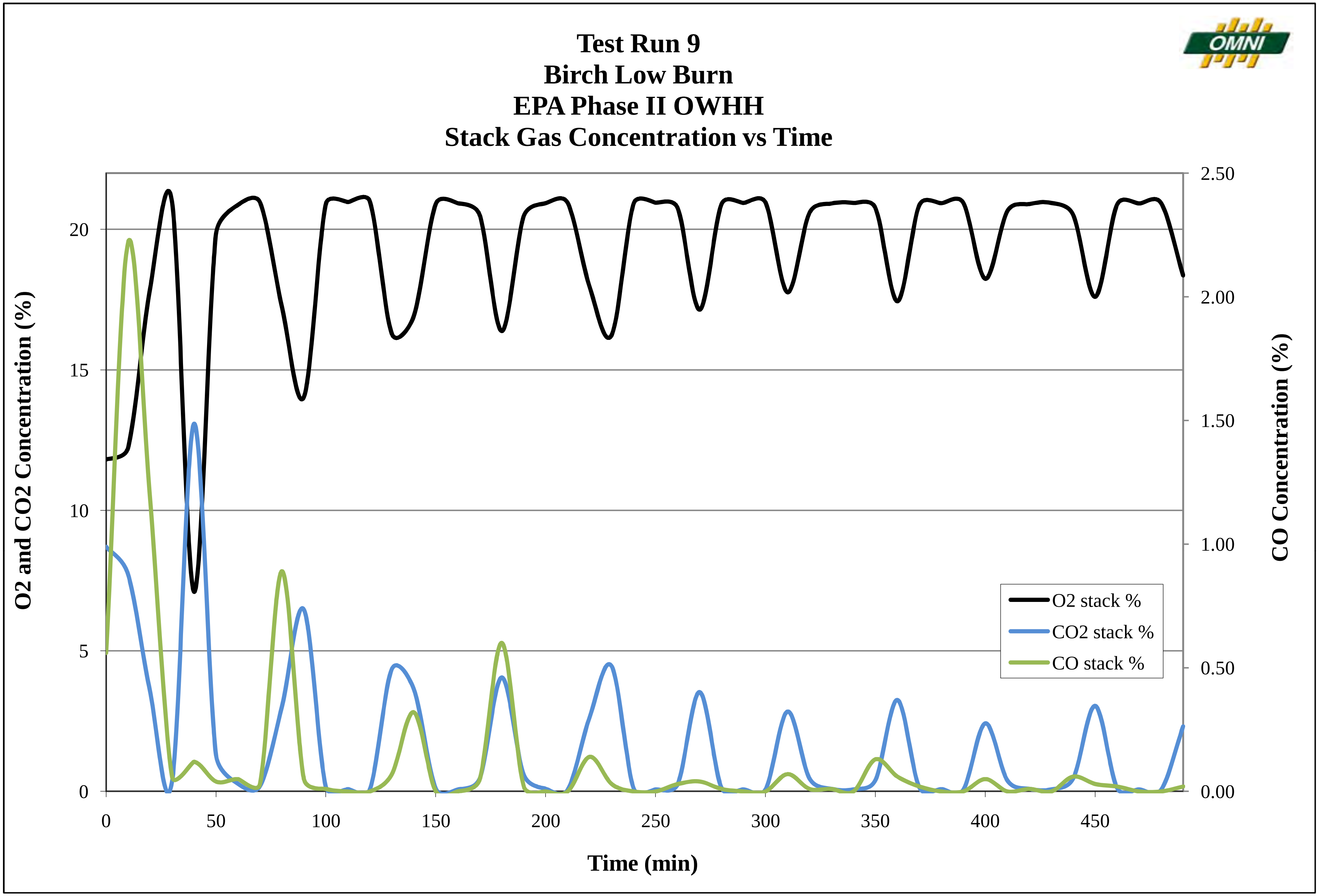

Test Run 5
Birch Low Burn
EPA Certified Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
50
100
150
200
250


Test Run 6
Spruce Low Burn
EPA Certified Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0
50
100
150
200
O2 stack %
CO2 stack %
CO stack %

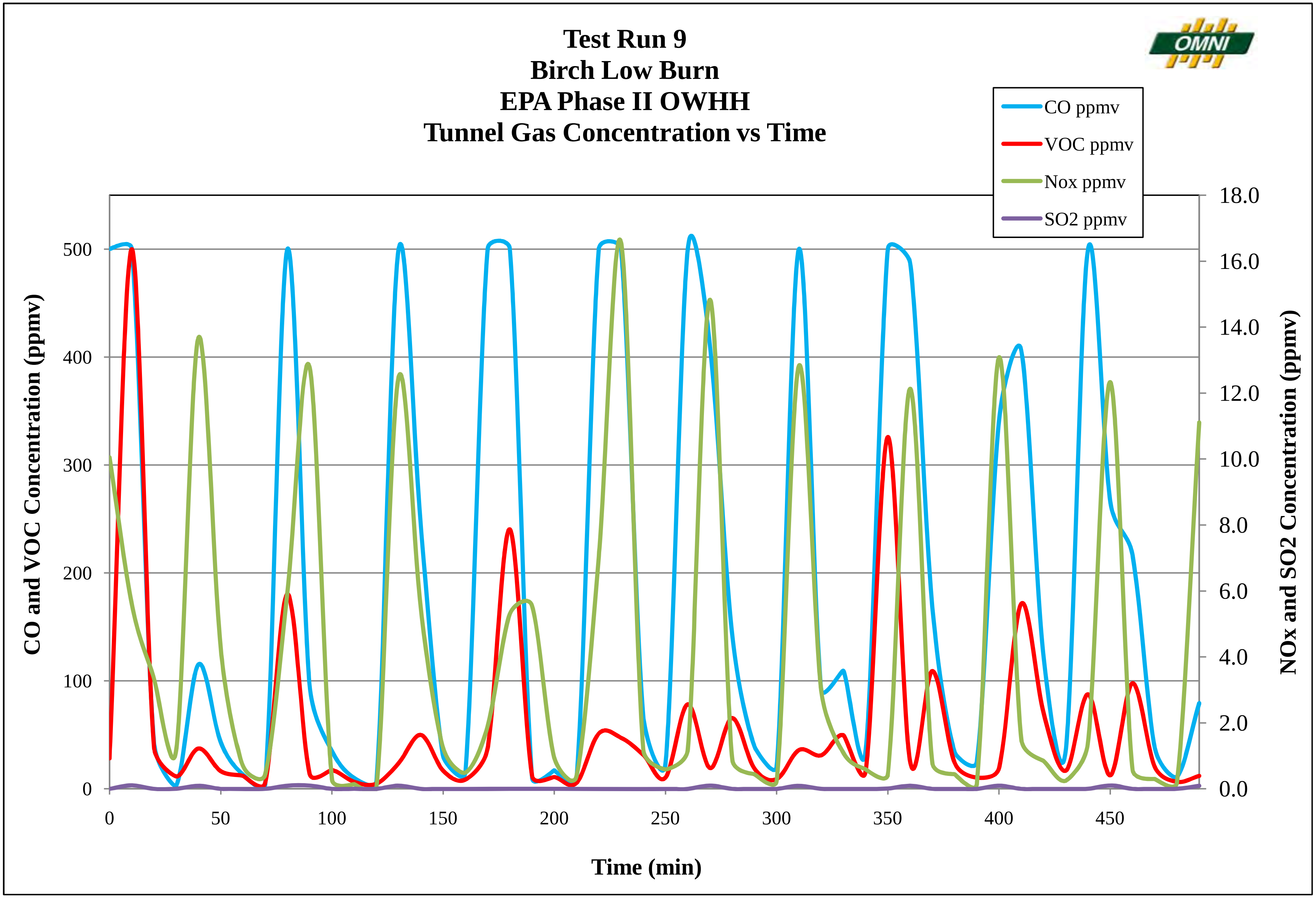

Test Run 6
Spruce Low Burn
EPA Certified Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
50
100
150
200
Time (min)

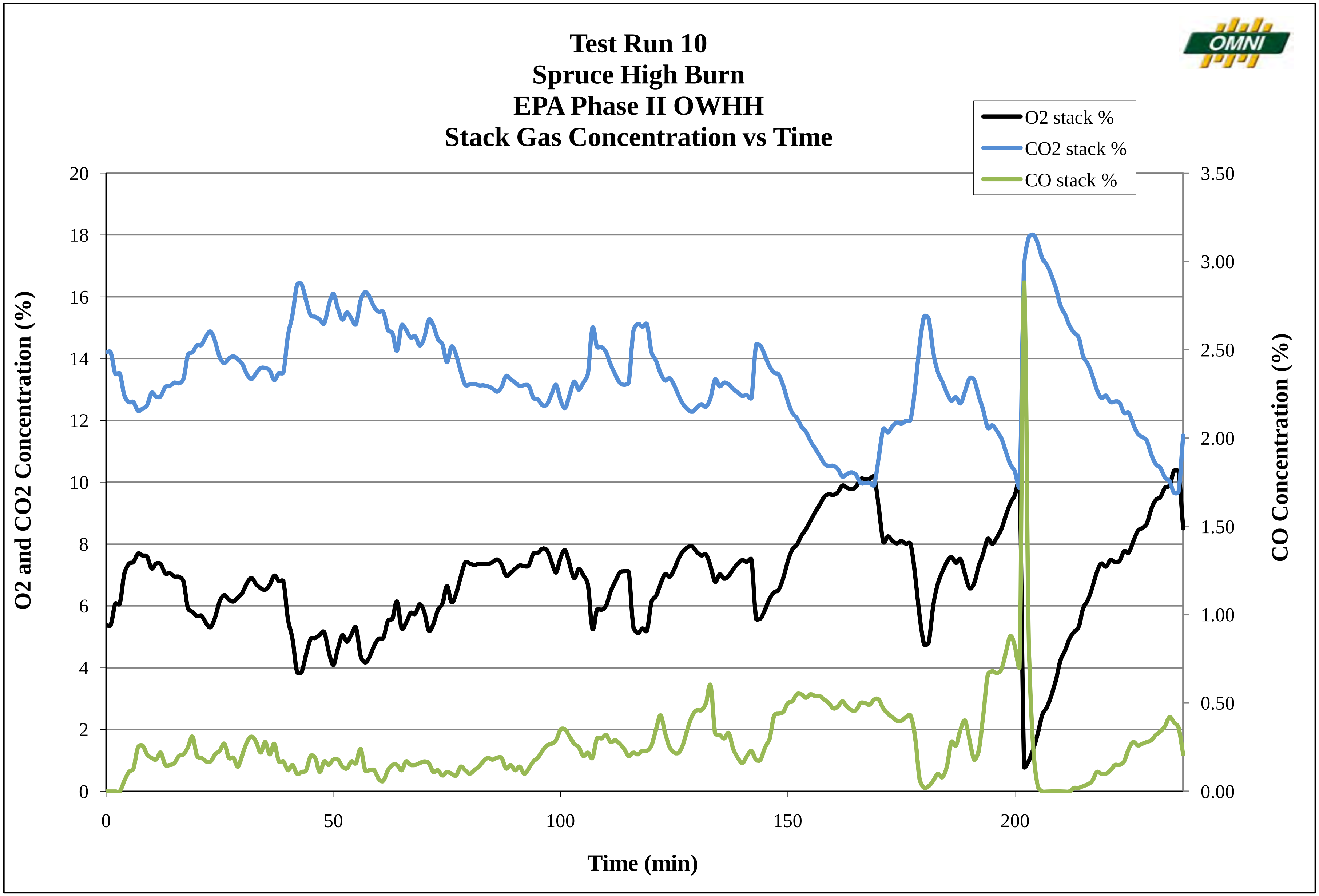

Test Run 8
Spruce High Burn
EPA Phase II OWHH
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200

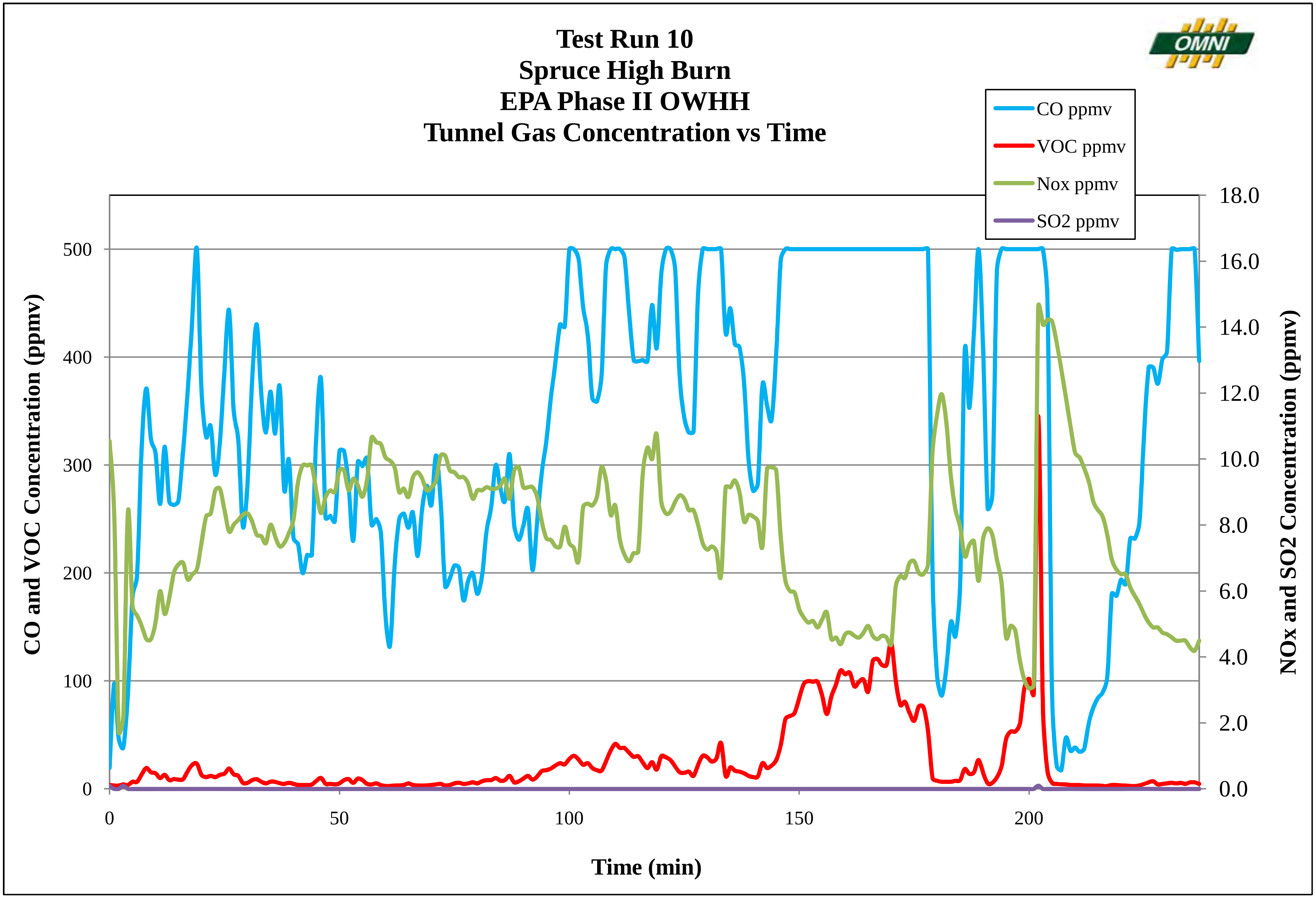

Test Run 8
Spruce High Burn
EPA Phase II OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
0
50
100
150
200

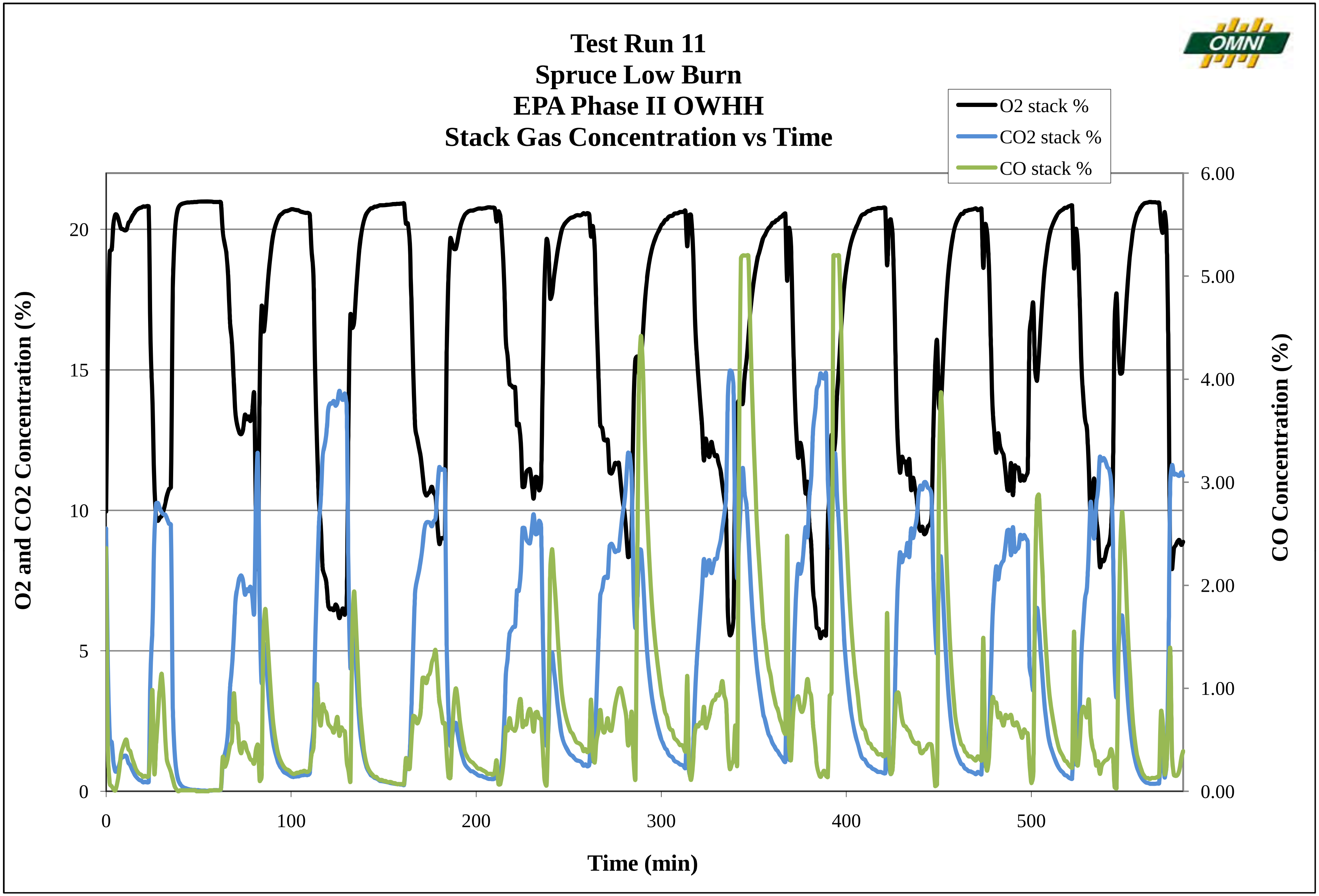


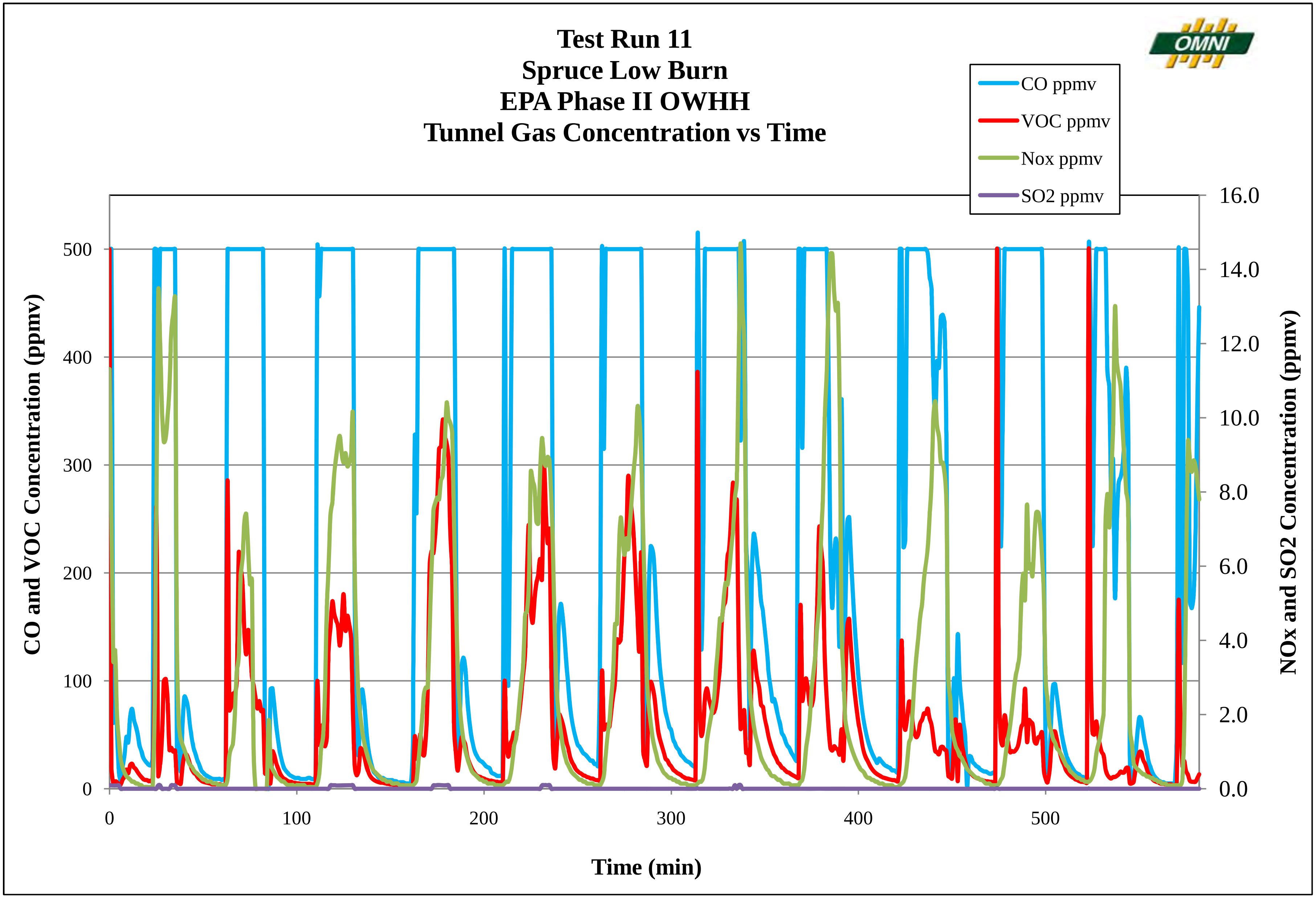
Test Run 9
Birch Low Burn
EPA Phase II OWHH
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
0.50
1.00
1.50
2.00
2.50
0
50
100
150
200
250
300
350
400
450
O2 stack %
CO2 stack %
CO stack %

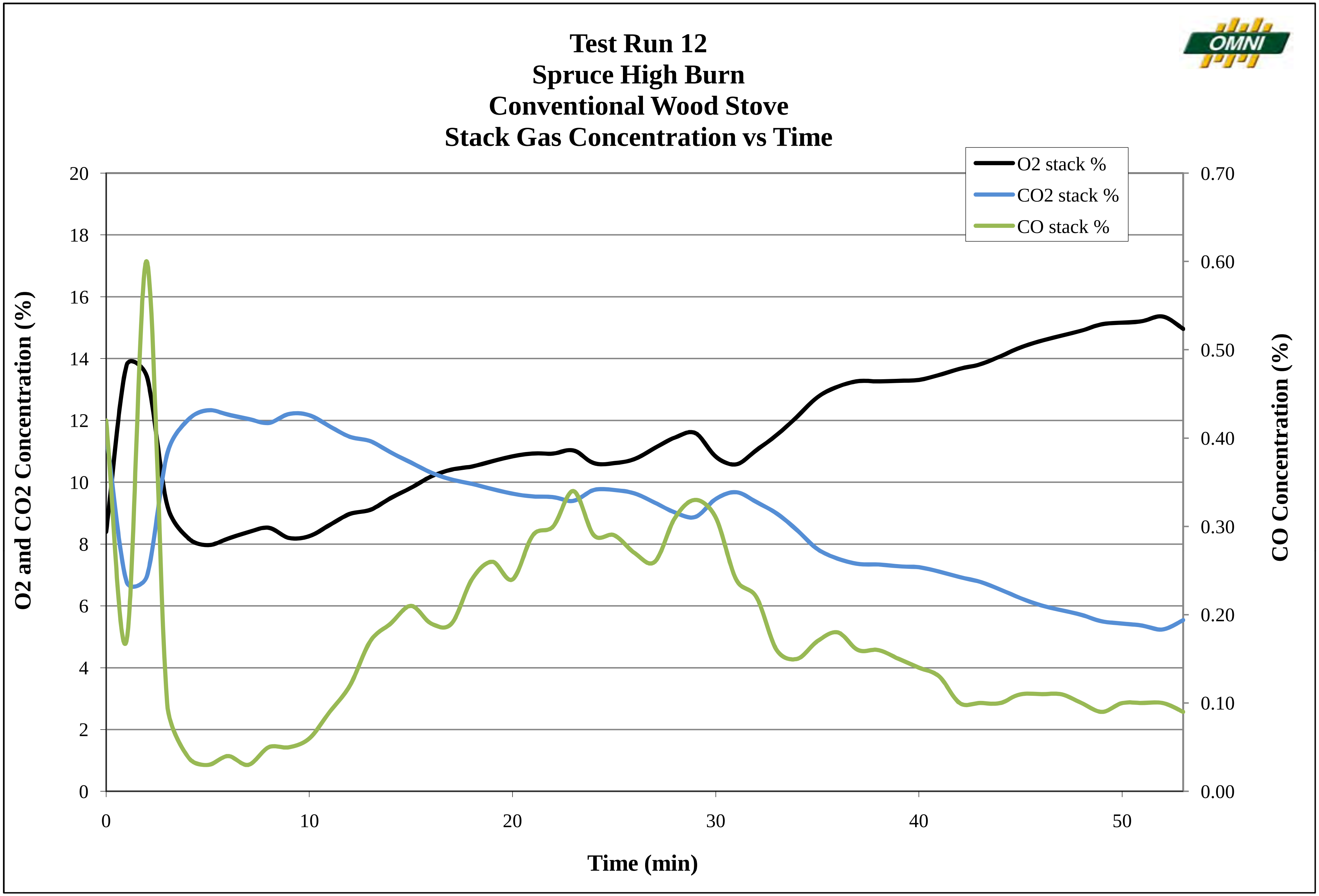

Test Run 9
Birch Low Burn
EPA Phase II OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
0
50
100
150
200
250
300
350
400
450

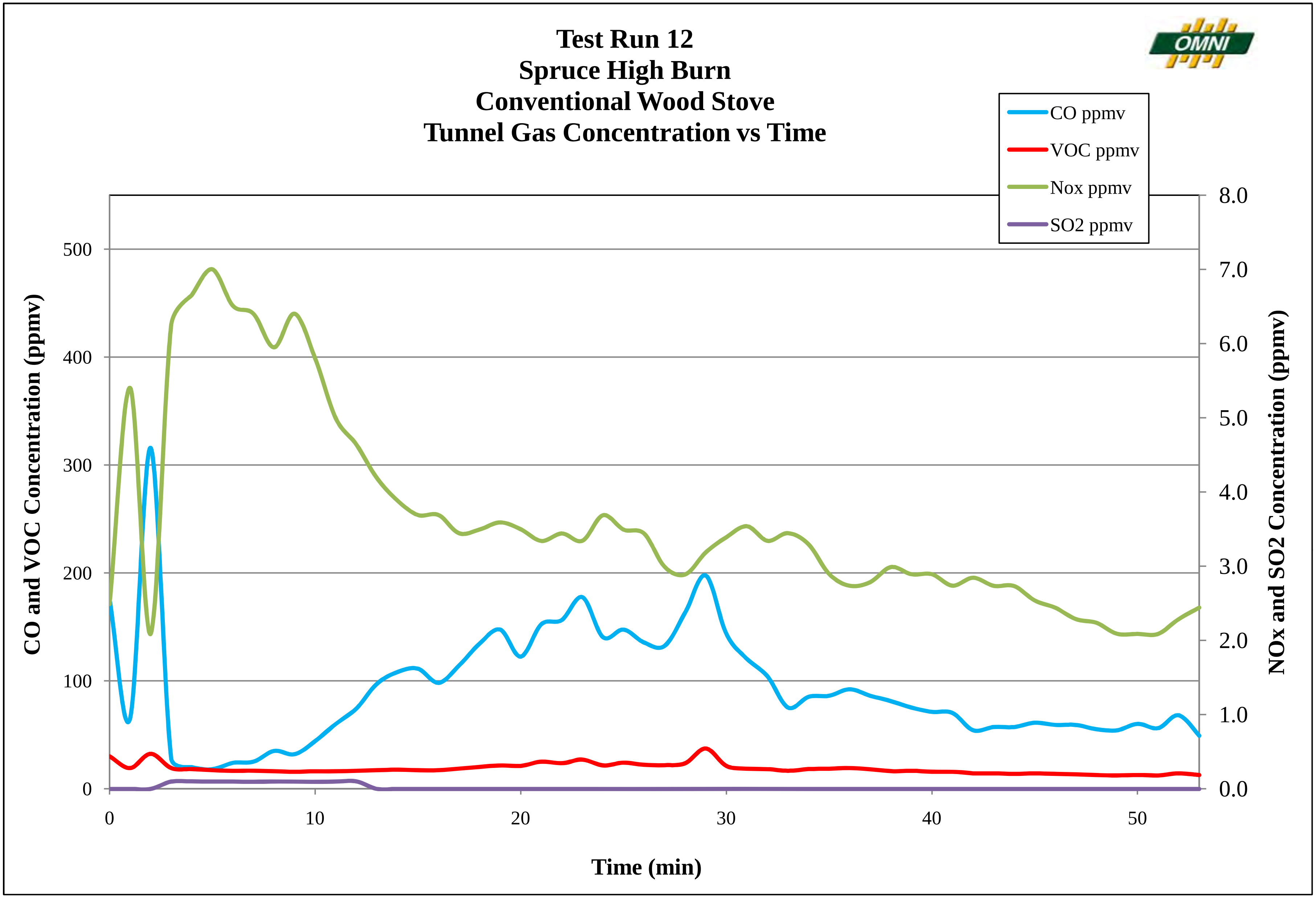

Test Run 10
Spruce High Burn
EPA Phase II OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
0
50
100
150
200

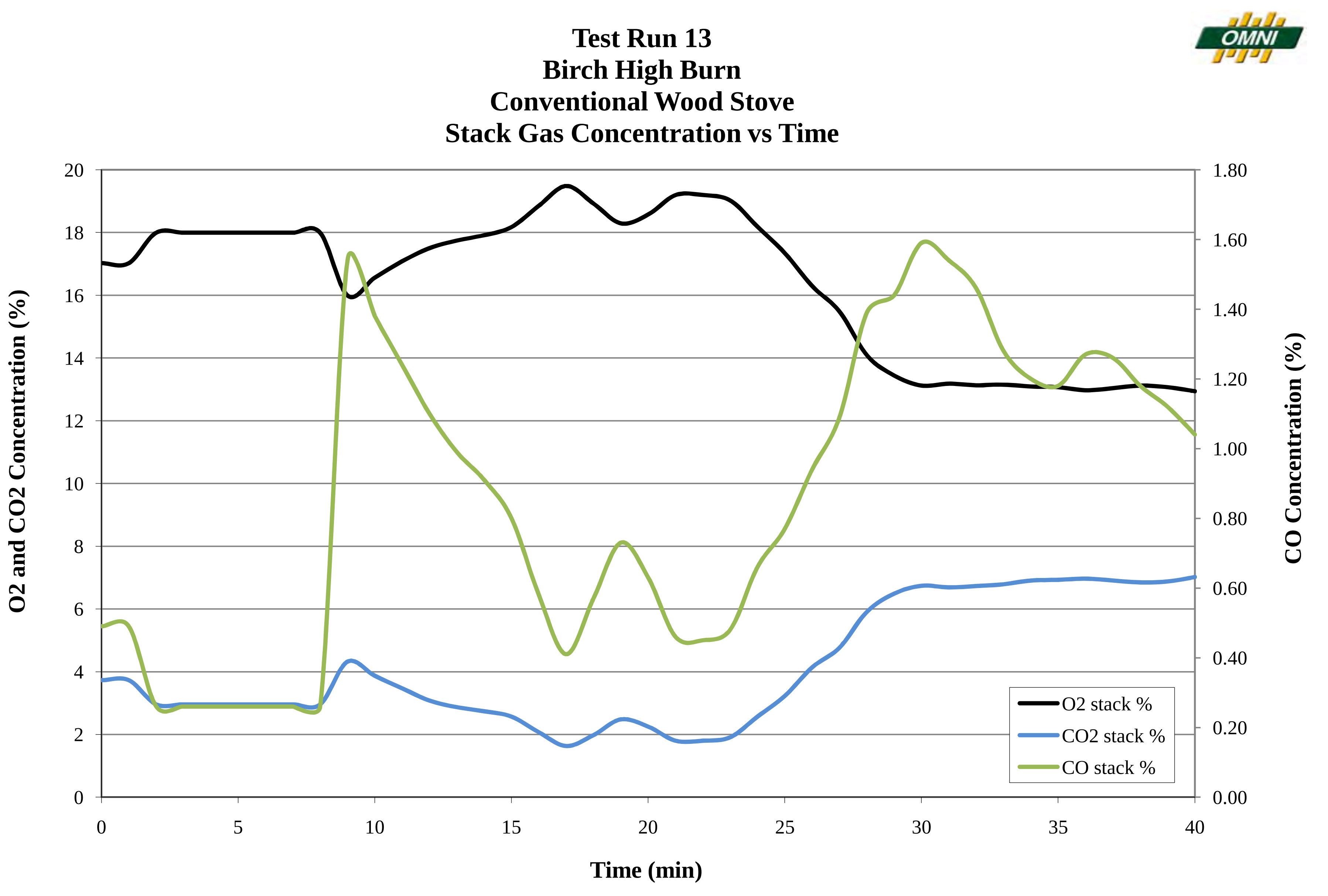

Test Run 10
Spruce High Burn
EPA Phase II OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
0
50
100
150
200
Time (min)

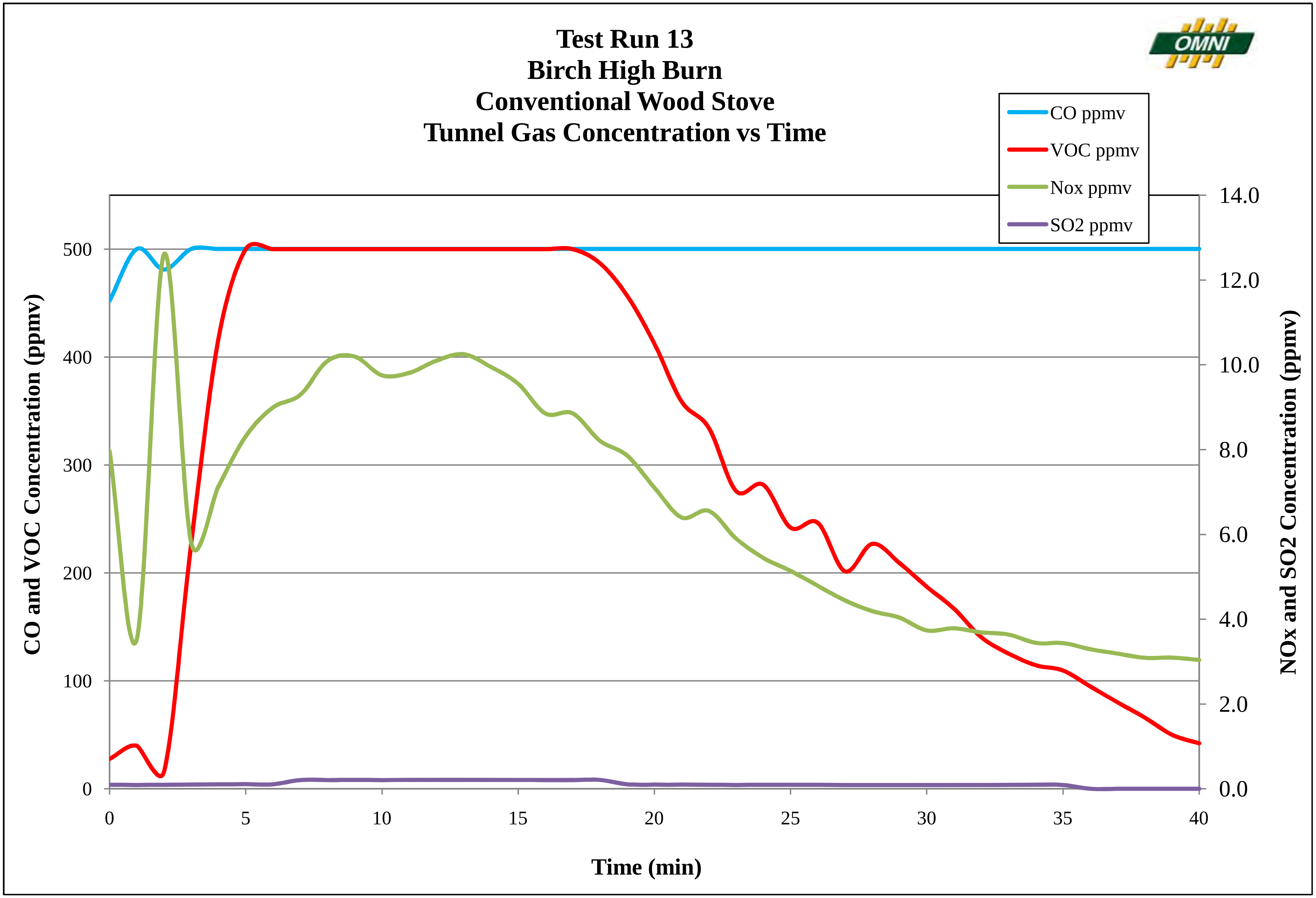

Test Run 11
Spruce Low Burn
EPA Phase II OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
100
200
300
400
500

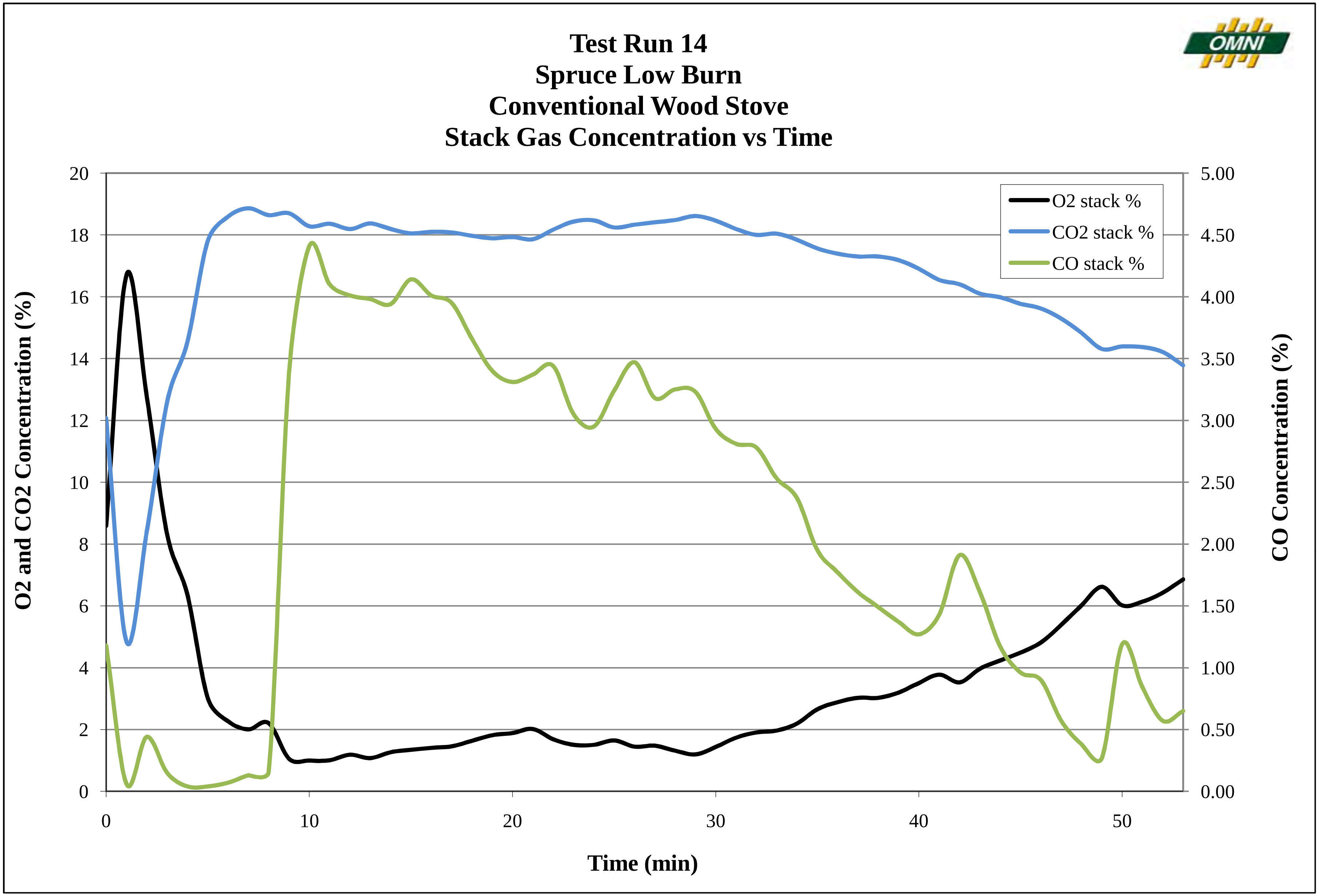

Test Run 11
Spruce Low Burn
EPA Phase II OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
0
100
200
300
400
500
Time (min)

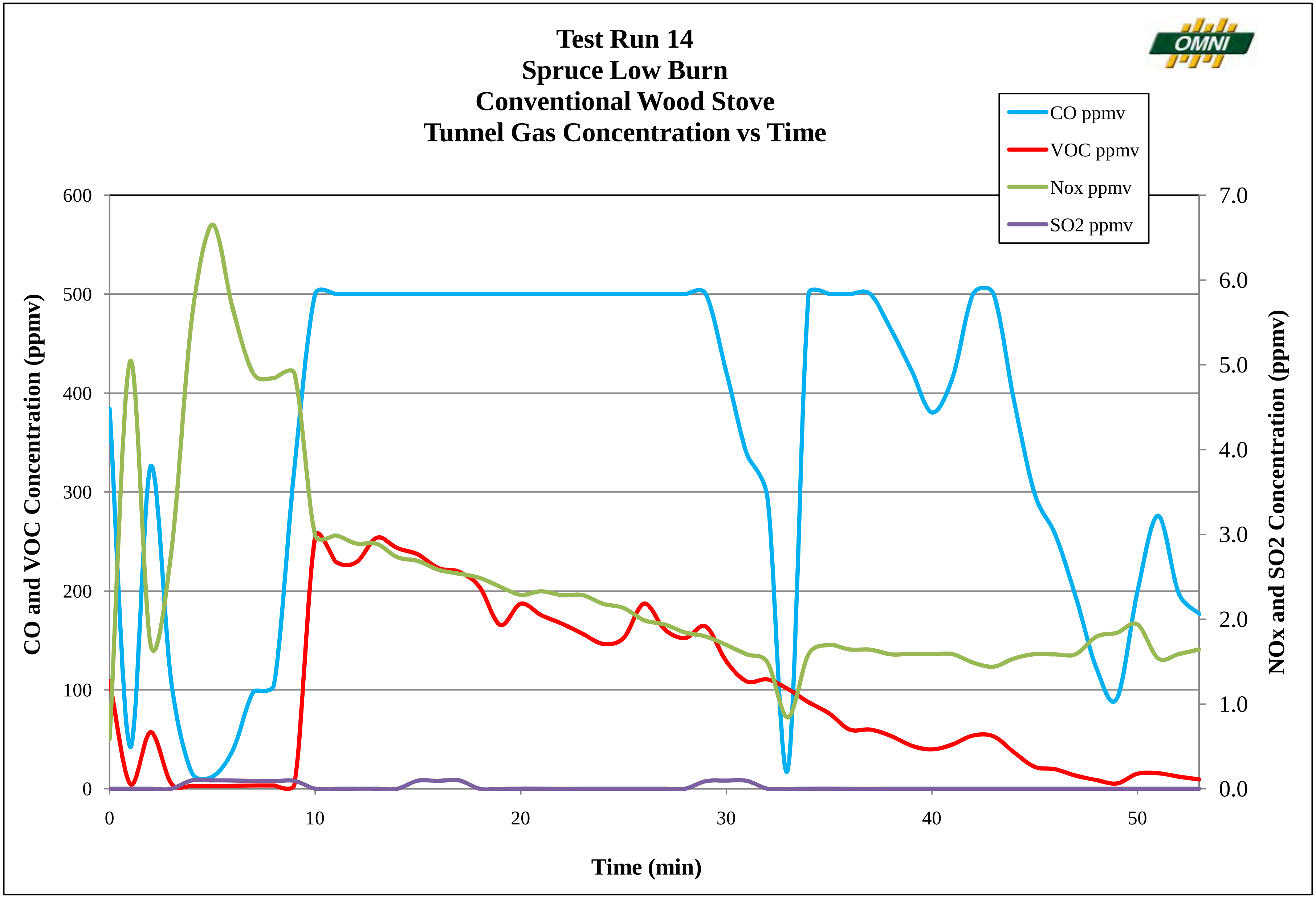

Test Run 12
Spruce High Burn
Conventional Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0
10
20
30
40
50

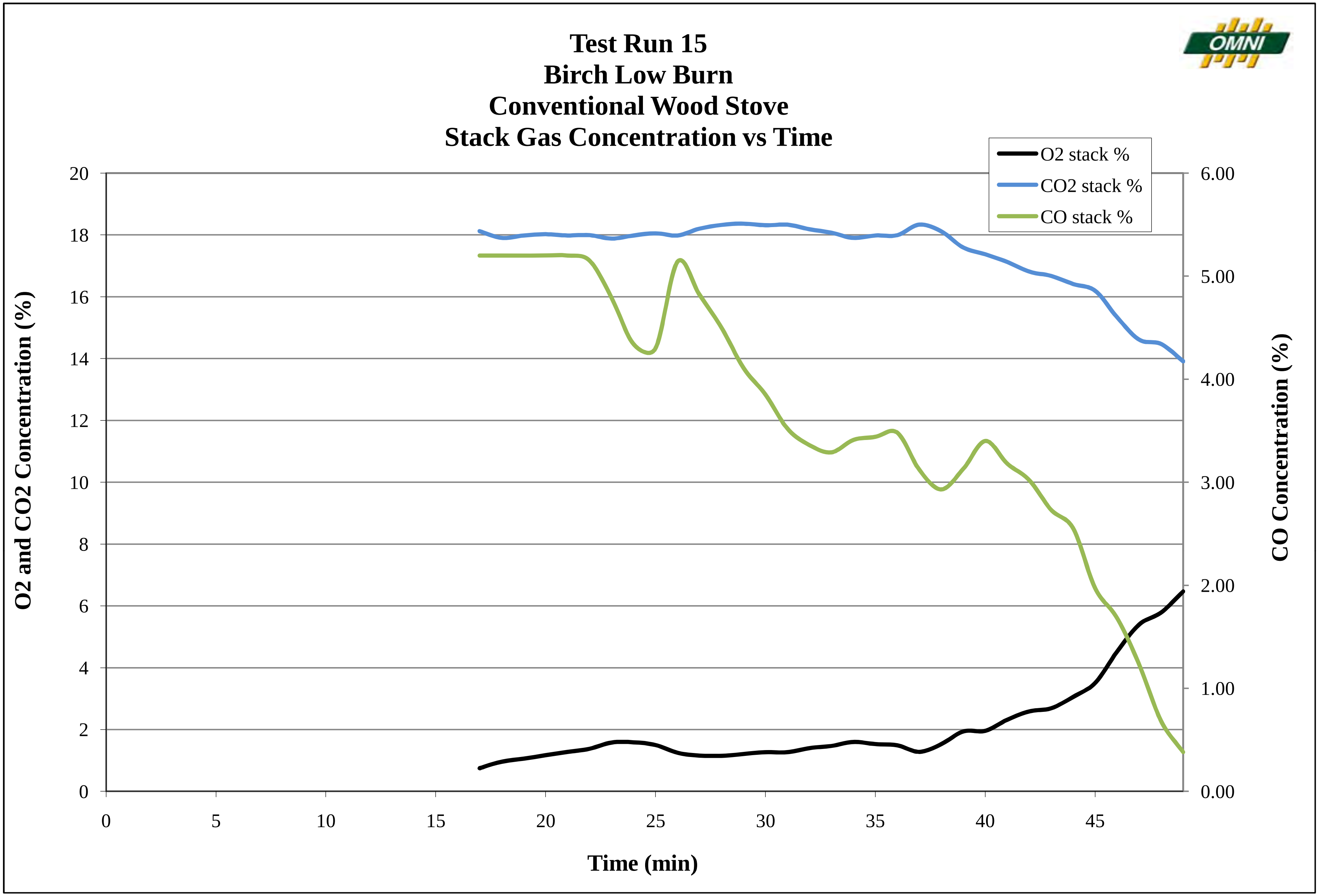

Test Run 12
Spruce High Burn
Conventional Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
0
10
20
30
40
50
Time (min)

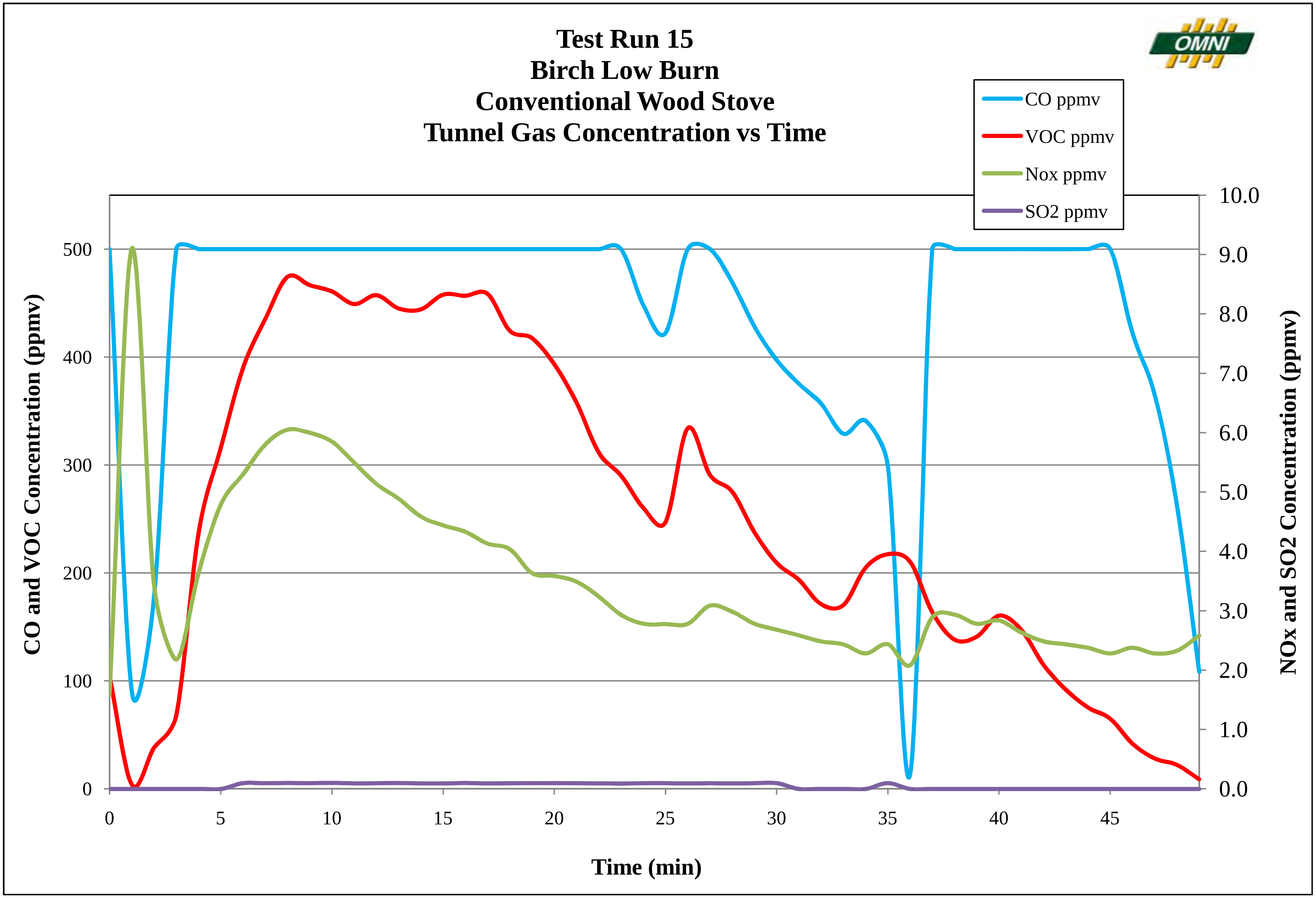

Test Run 13
Birch High Burn
Conventional Wood Stove
Stack Gas Concentration vs Time
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
0
5
10
15
20
25
30
35
40

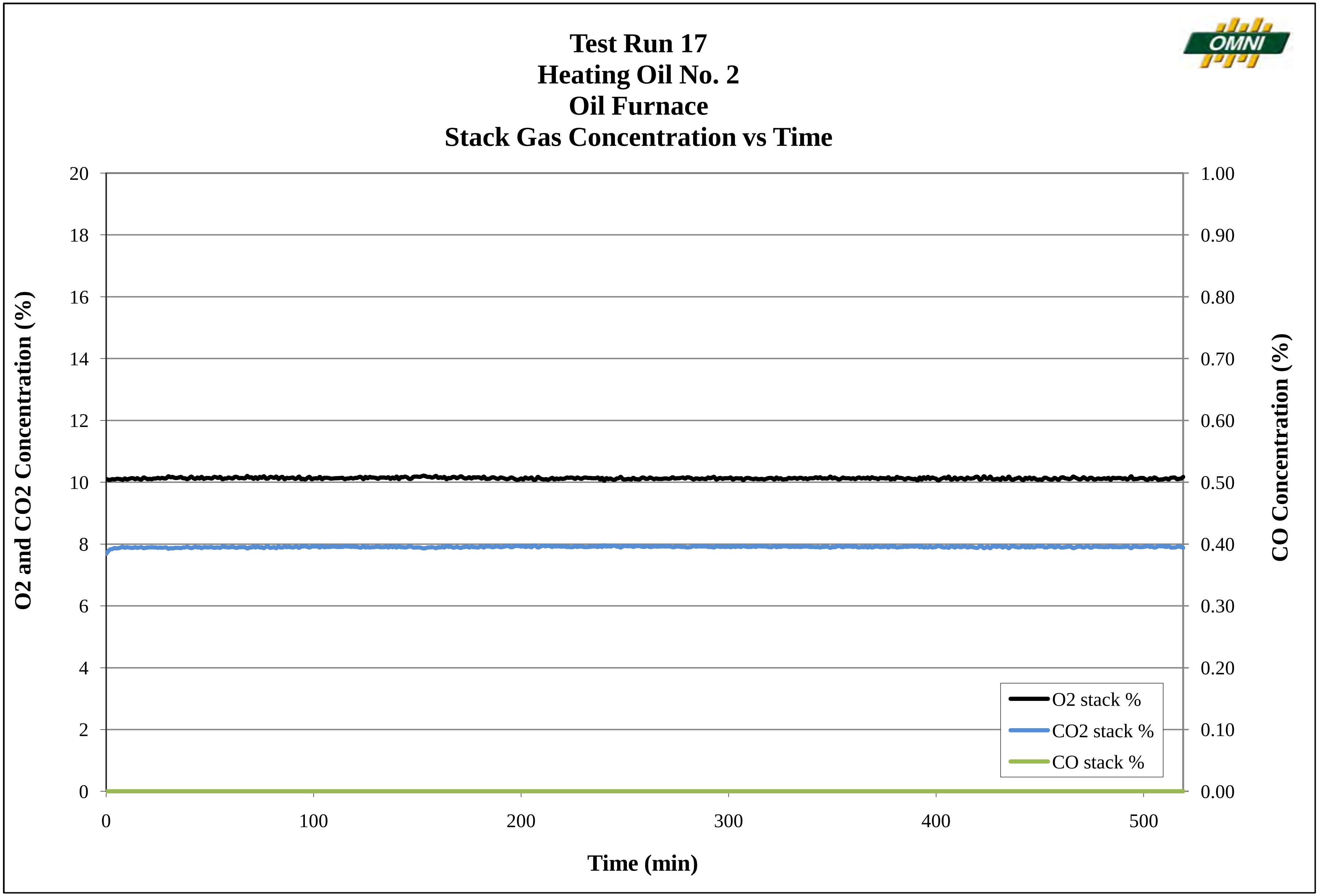

Test Run 13
Birch High Burn
Conventional Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0
5
10
15
20
25
30
35
40

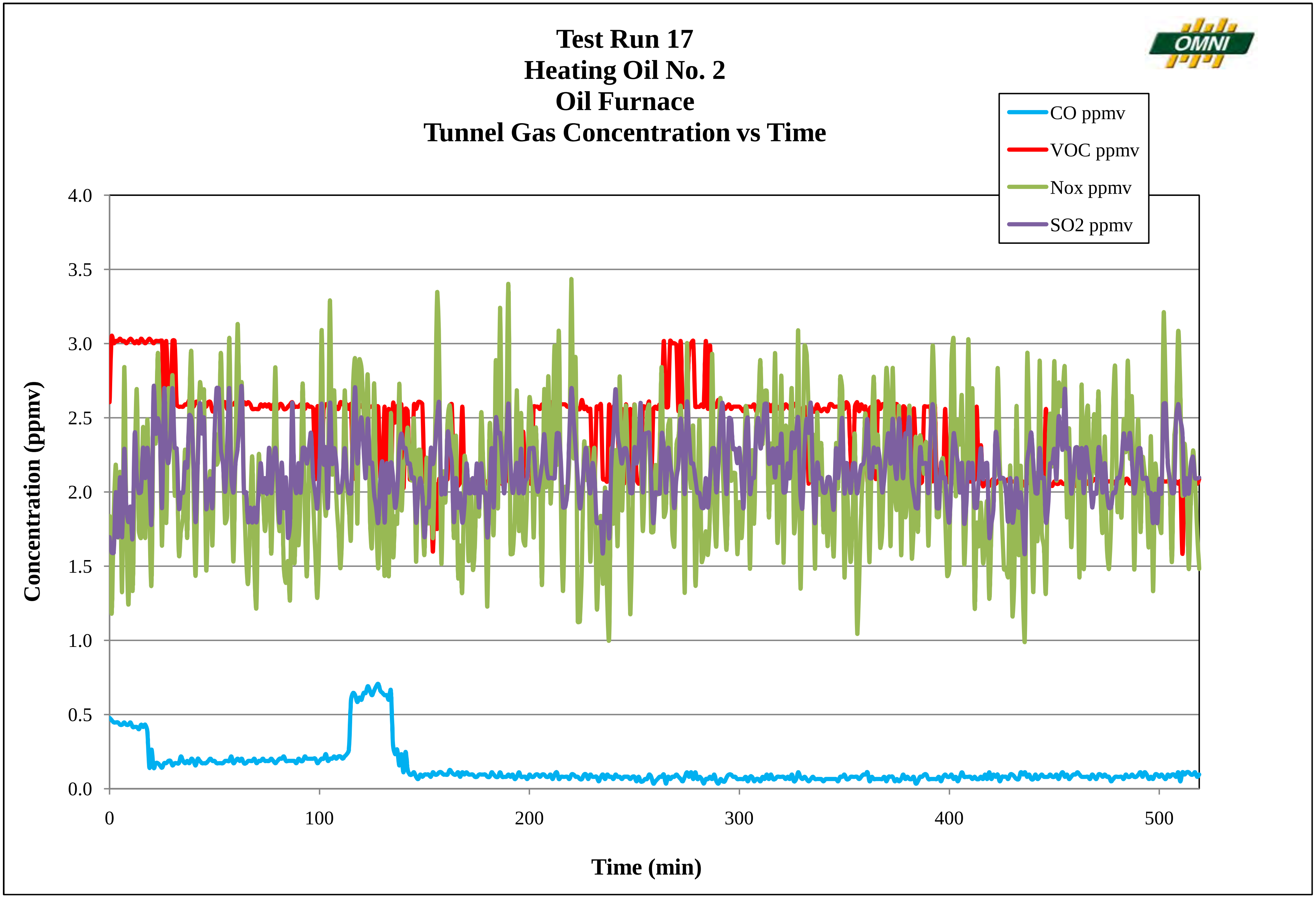

Test Run 14
Spruce Low Burn
Conventional Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
10
20
30
40
50

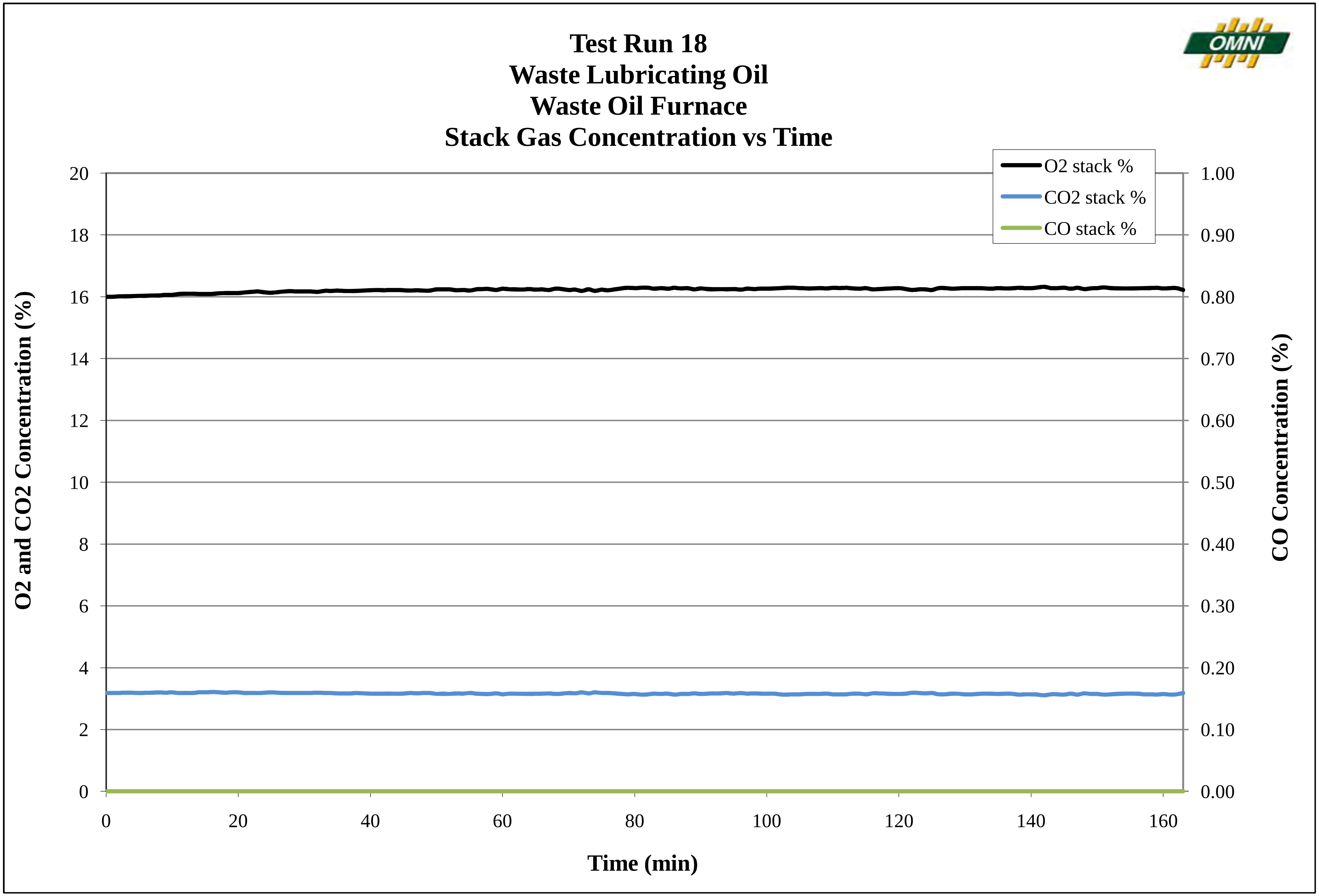

Test Run 14
Spruce Low Burn
Conventional Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
600
NOx and SO2 Concentration (ppmv)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0
10
20
30
40
50
Time (min)

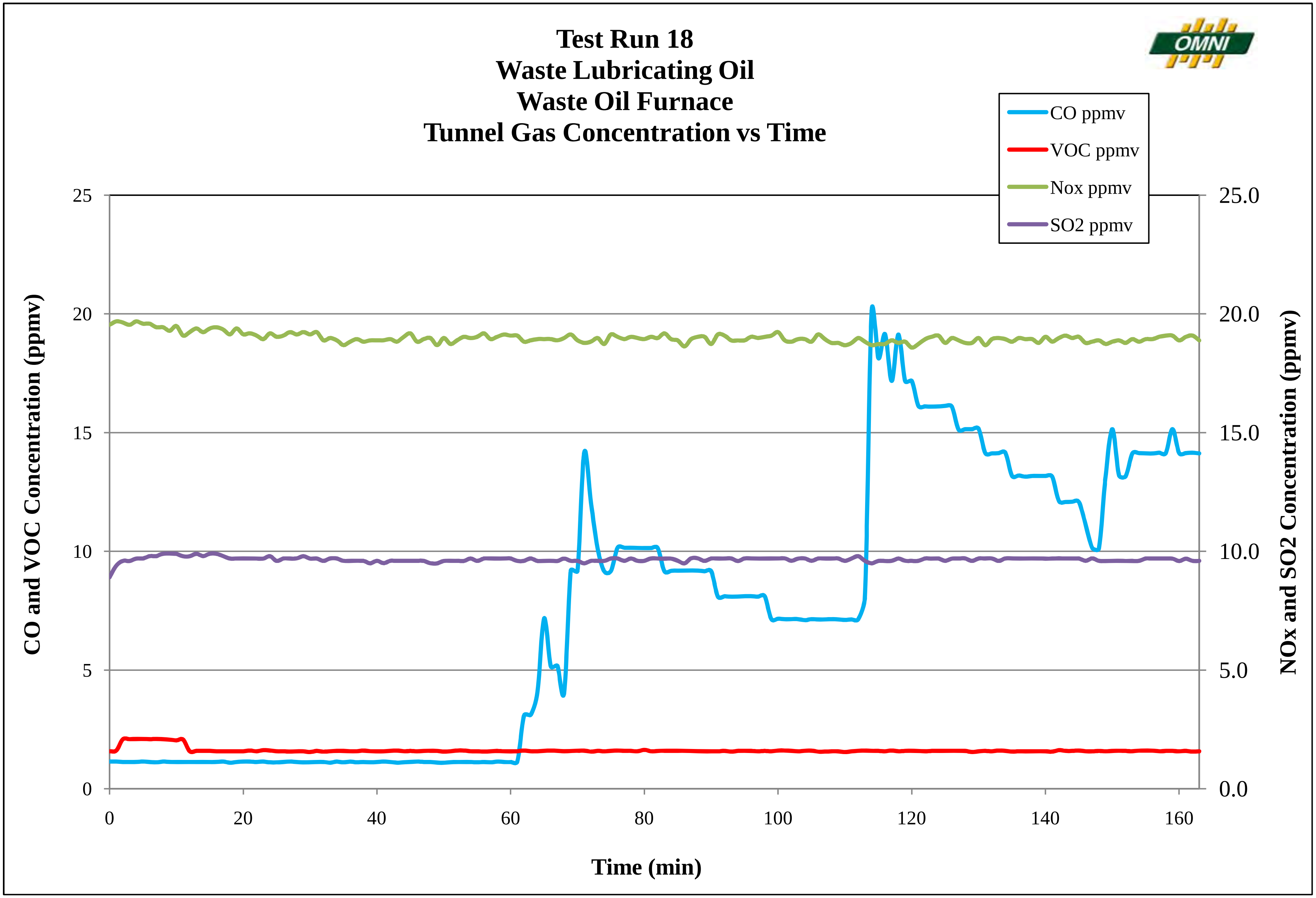

Test Run 15
Birch Low Burn
Conventional Wood Stove
Stack Gas Concentration vs Time
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
5
10
15
20
25
30
35
40
45

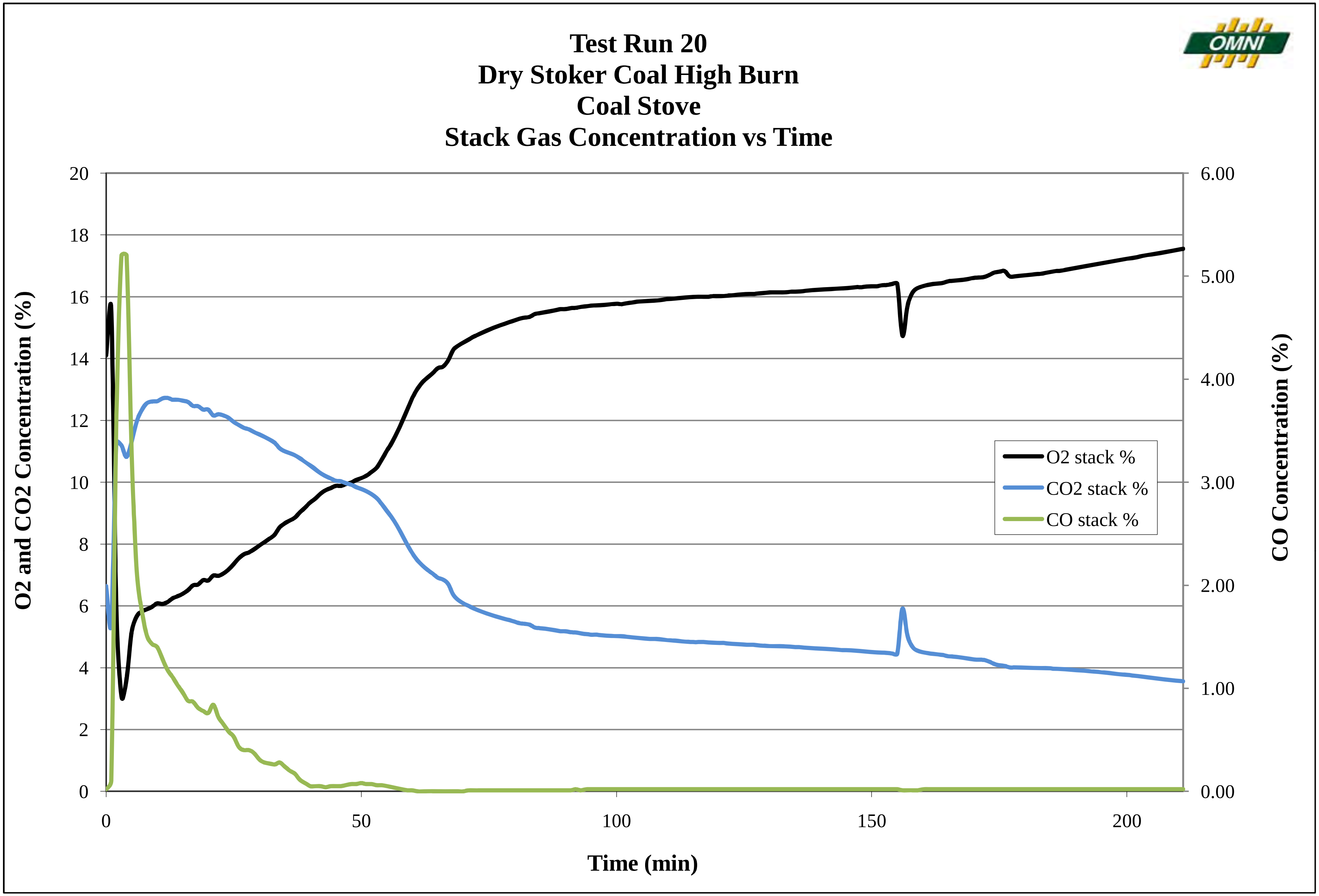

Test Run 15
Birch Low Burn
Conventional Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0
5
10
15
20
25
30
35
40
45

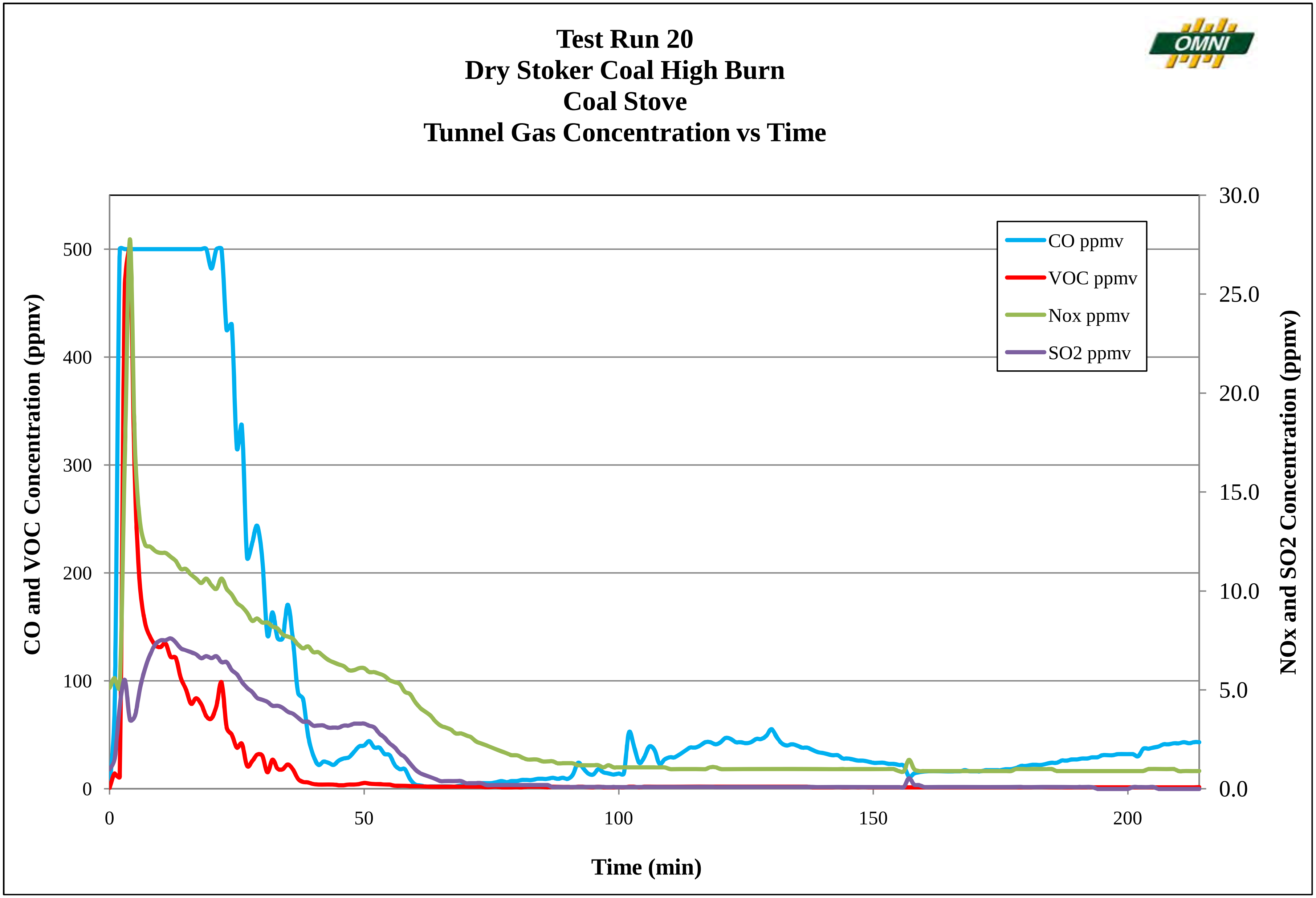

Test Run 17
Heating Oil No. 2
Oil Furnace
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
20
18
16
14
12
10
8
6
4
2
0
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
100
200
300
400
500
Time (min)
O2 stack %
CO2 stack %
CO stack %

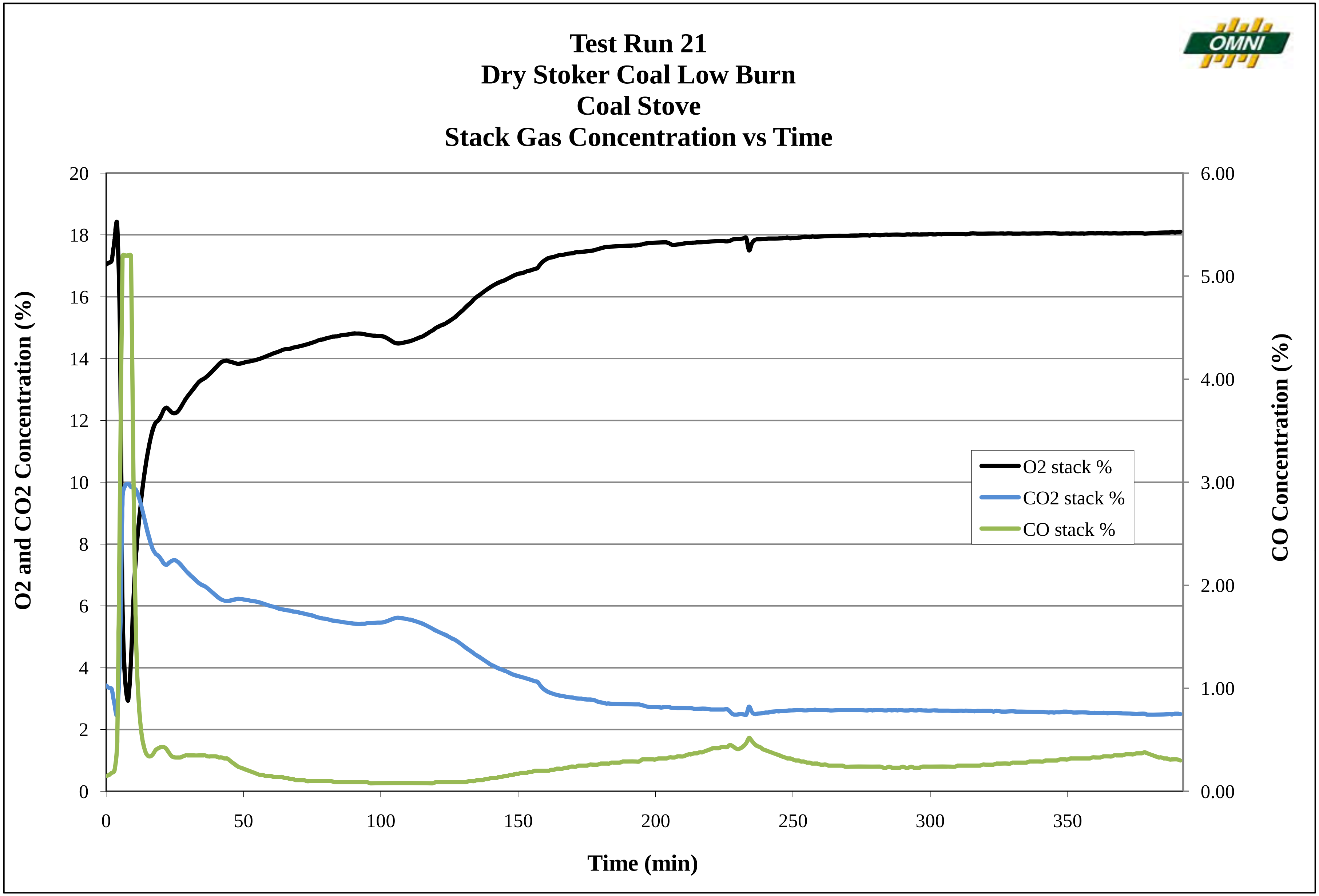

Test Run 17
Heating Oil No. 2
Oil Furnace
Tunnel Gas Concentration vs Time
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
Concentration (ppmv)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
Time (min)

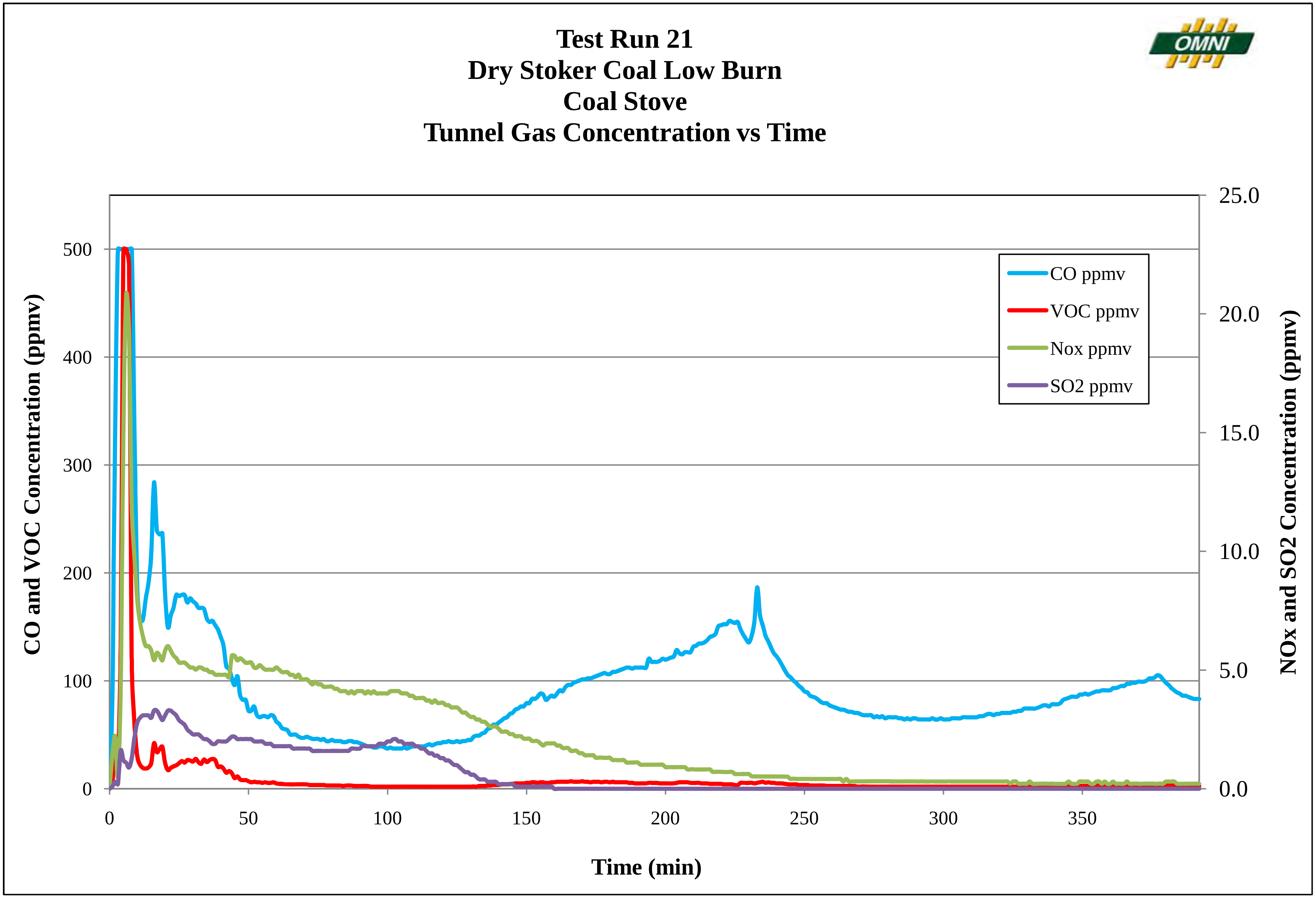

Test Run 18
Waste Lubricating Oil
Waste Oil Furnace
Stack Gas Concentration vs Time
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
20
40
60
80
100
120
140
160
2
4
6
8
10
12
14
16
18
20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

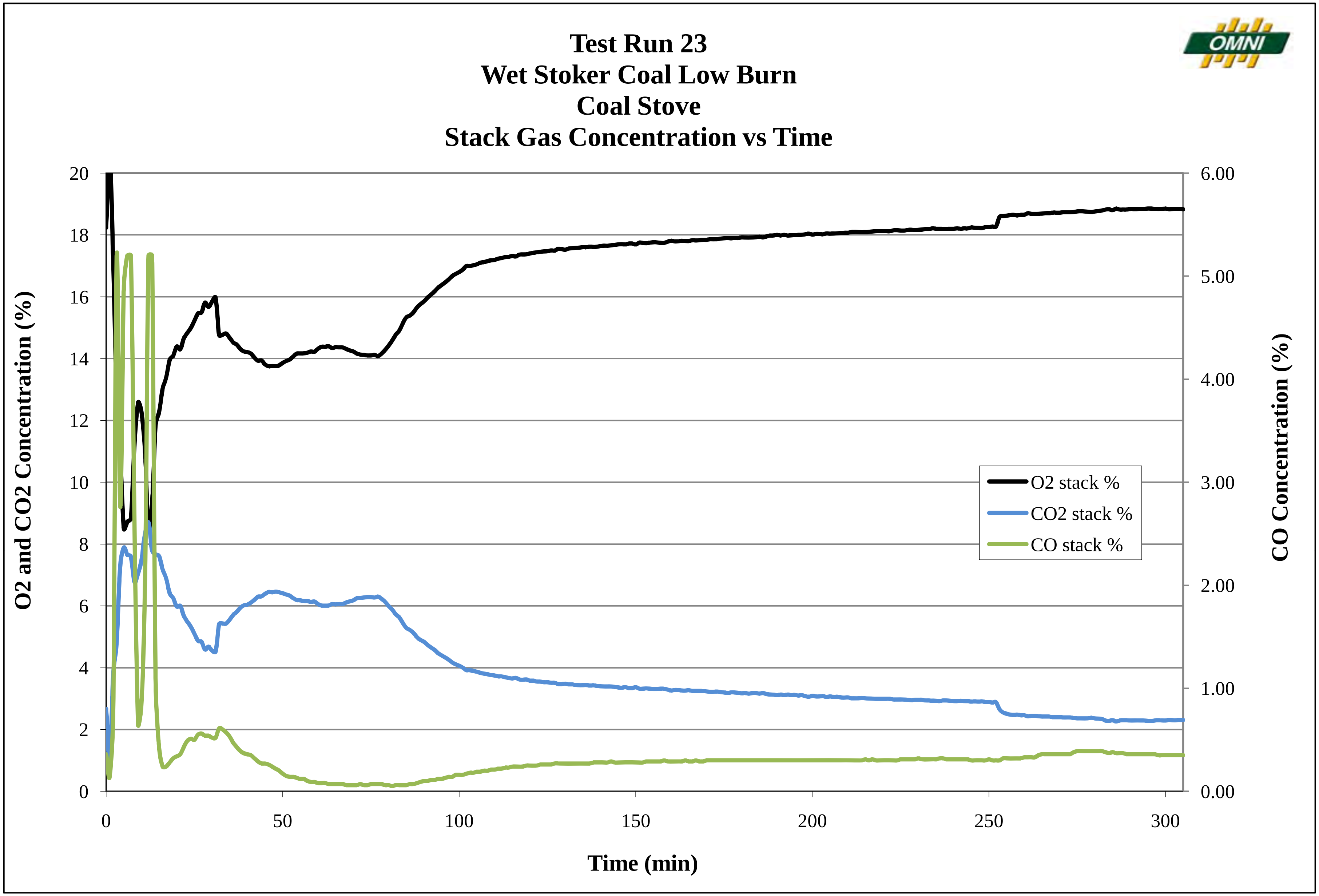

Test Run 18
Waste Lubricating Oil
Waste Oil Furnace
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
5
10
15
20
25
0.0
5.0
10.0
15.0
20.0
25.0
0
20
40
60
80
100
120
140
160

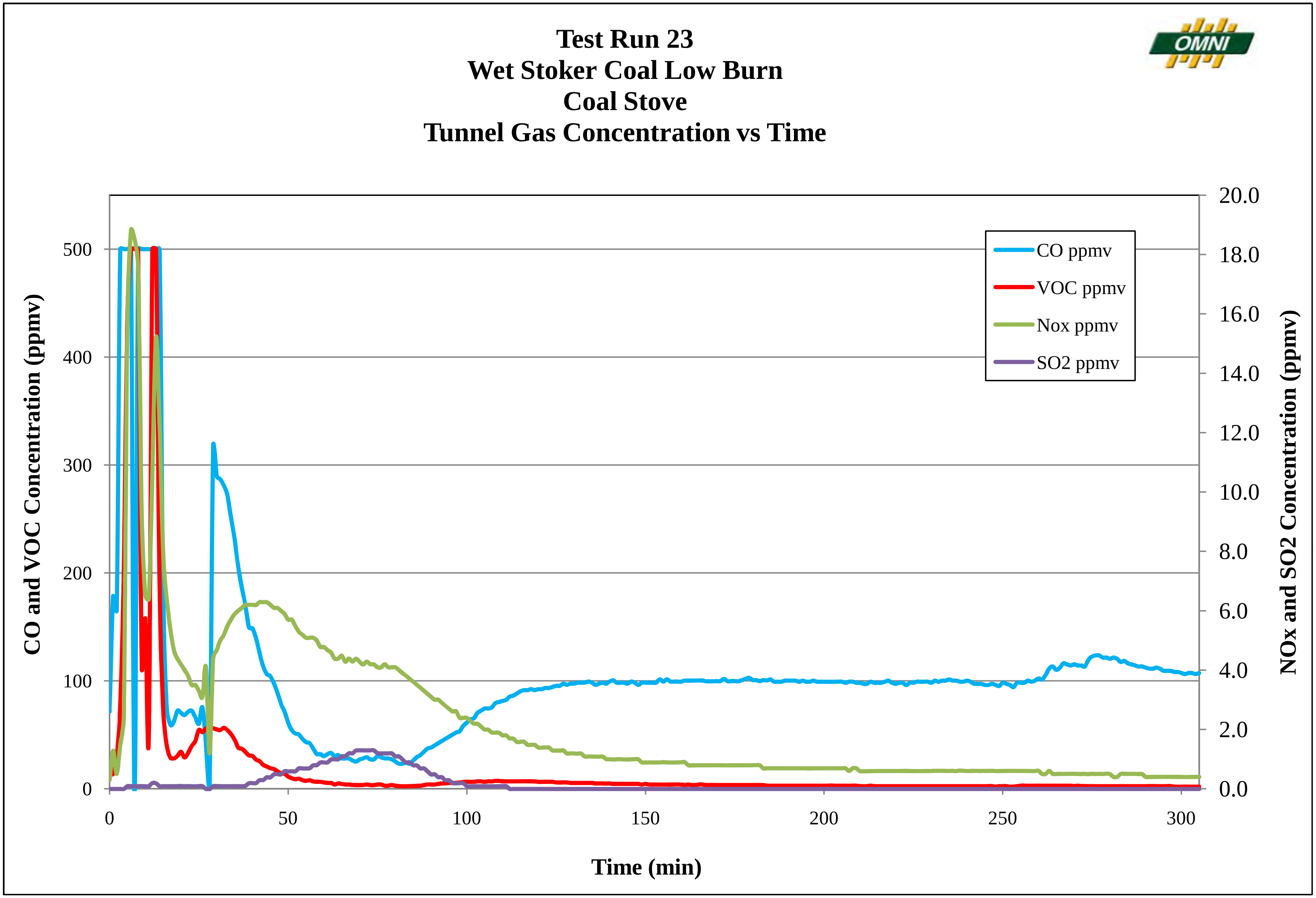

Test Run 20
Dry Stoker Coal High Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200

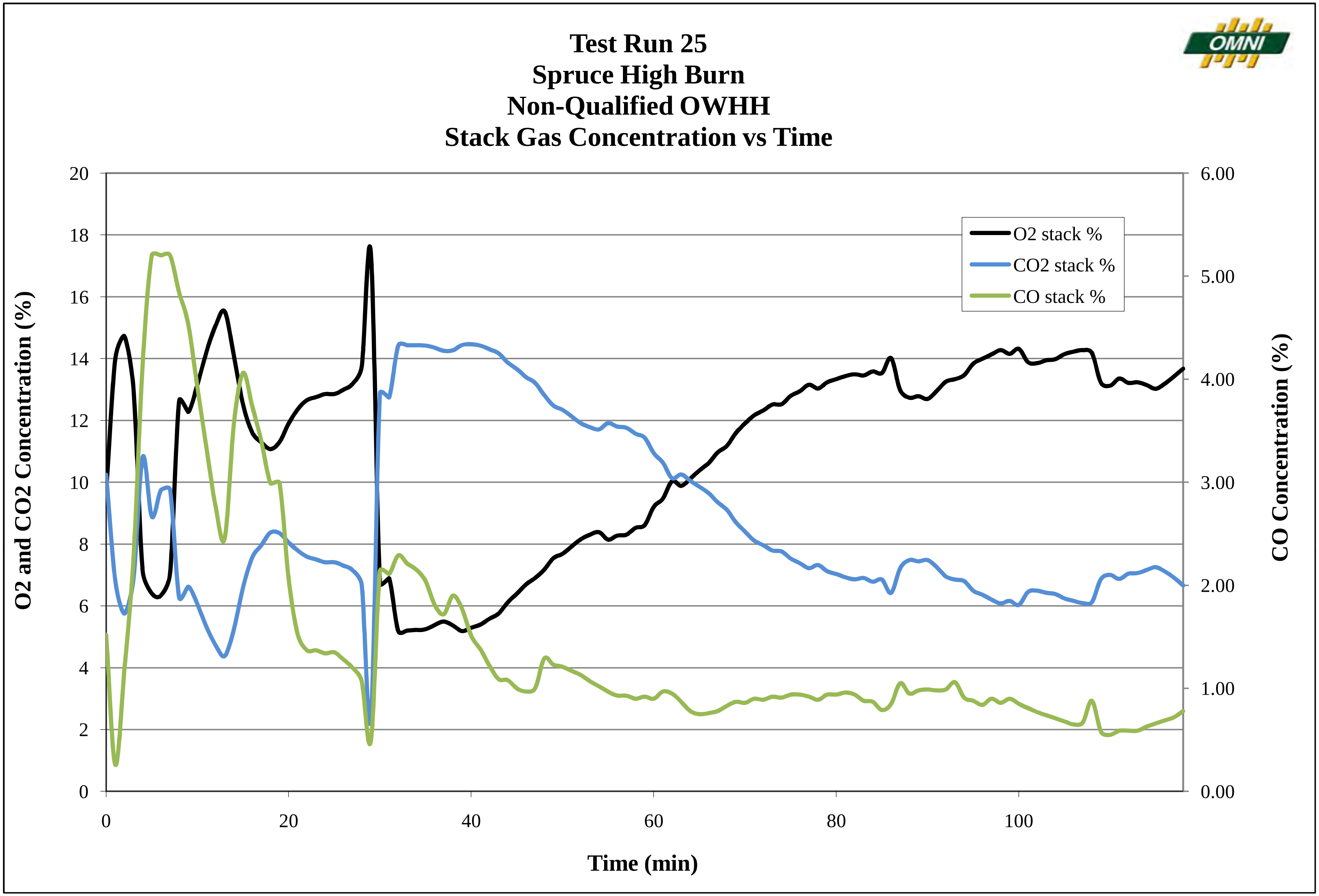

Test Run 20
Dry Stoker Coal High Burn
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
30.0
0
50
100
150
200

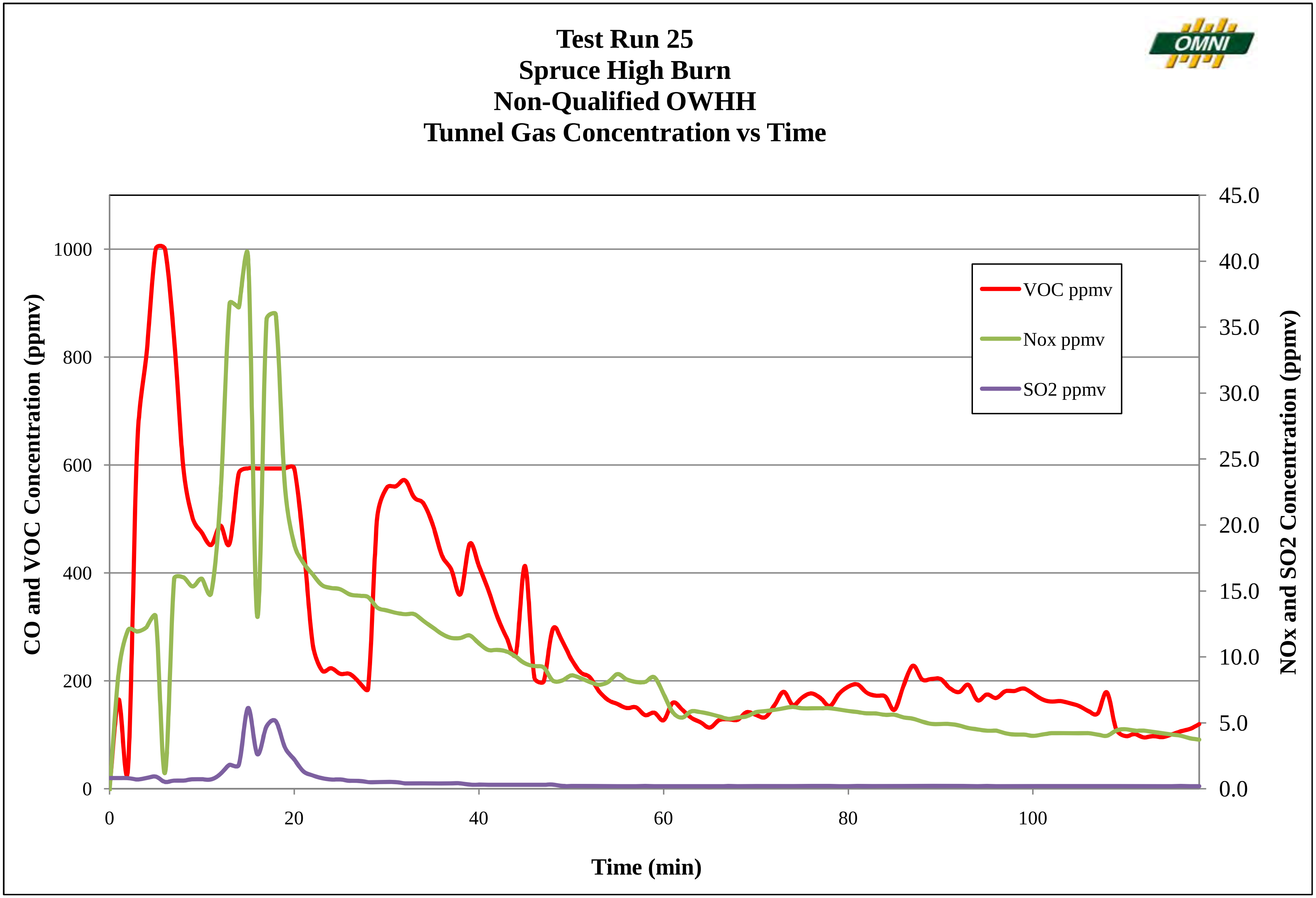

Test Run 21
Dry Stoker Coal Low Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
20
18
16
14
12
10
8
6
4
2
0
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
50
100
150
200
250
300
350

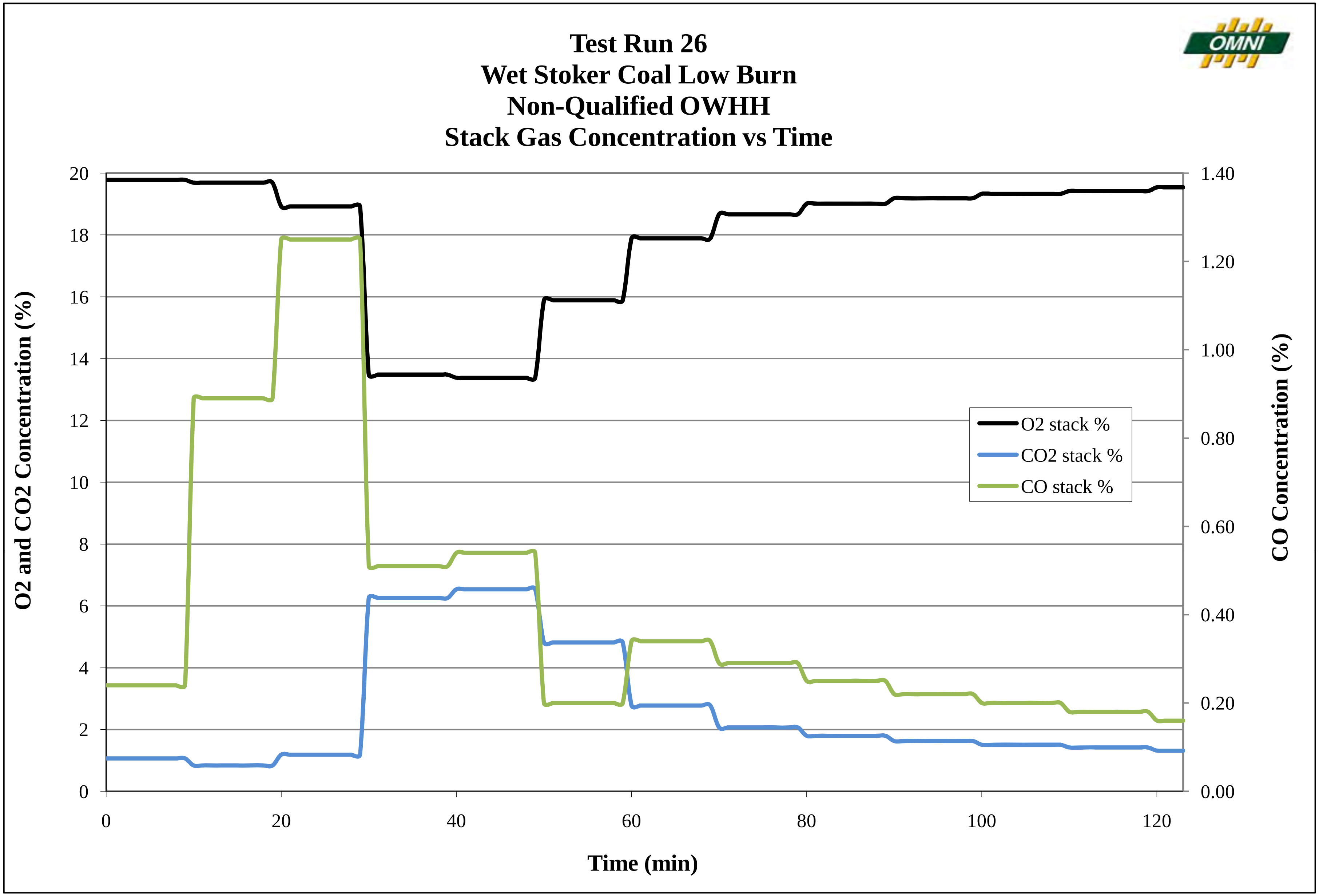

Test Run 21
Dry Stoker Coal Low Burn
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
0
50
100
150
200
250
300
350
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv

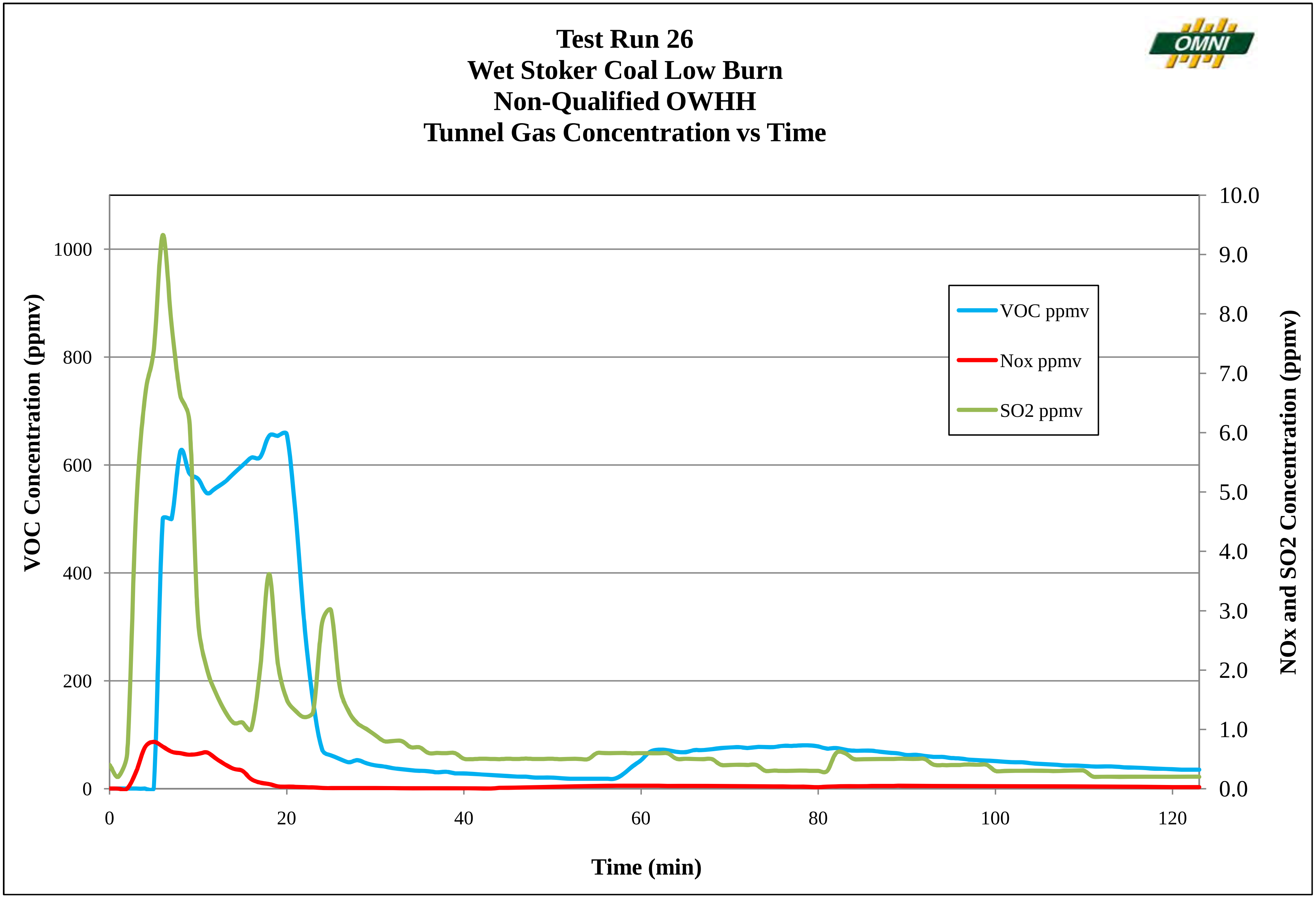

Test Run 23
Wet Stoker Coal Low Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200
250
300

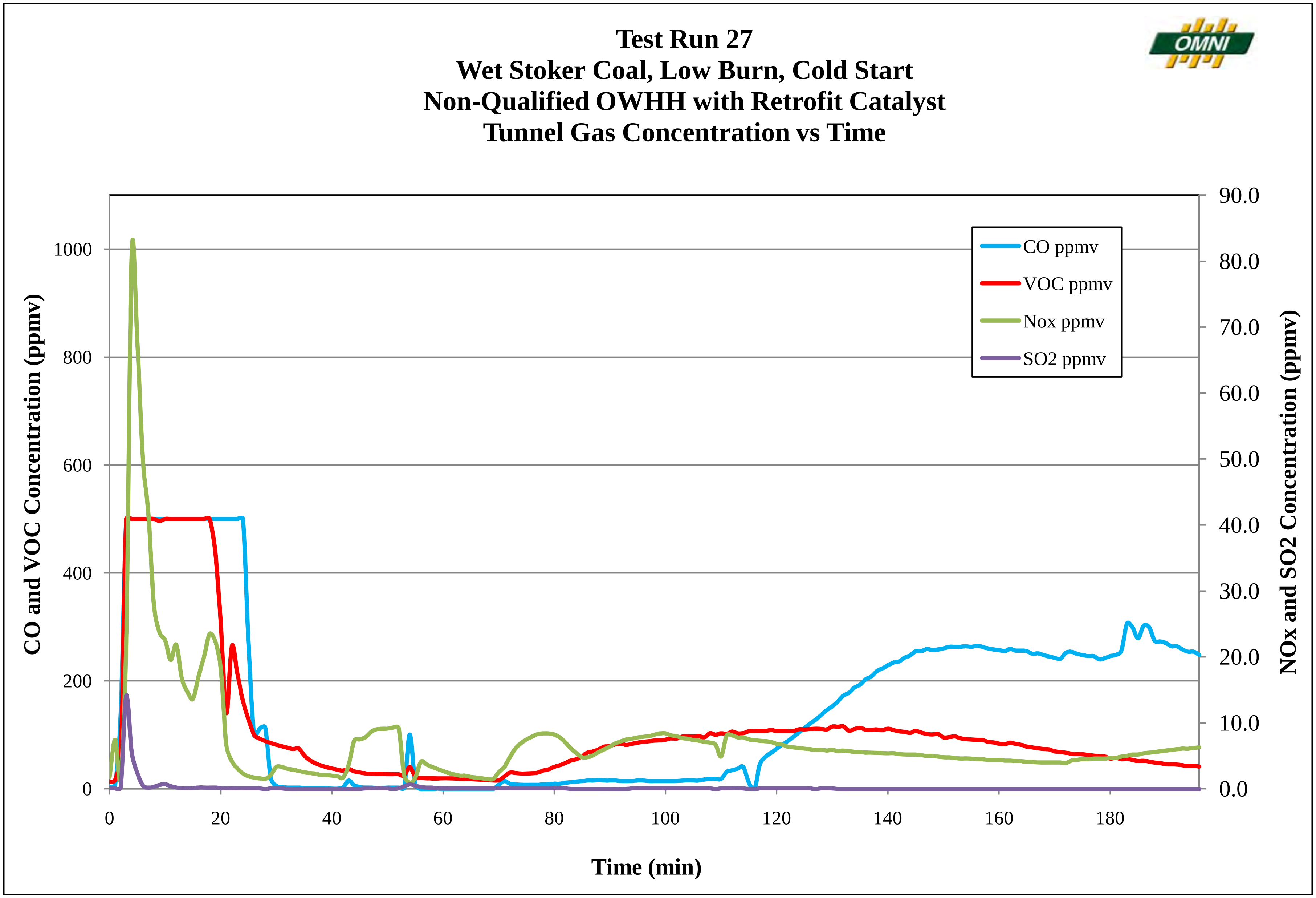

Test Run 23
Wet Stoker Coal Low Burn
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
0
100
200
300
400
500
NOx and SO2 Concentration (ppmv)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Time (min)
0
50
100
150
200
250
300
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv


Test Run 25
Spruce High Burn
Non-Qualified OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
20
40
60
80
100

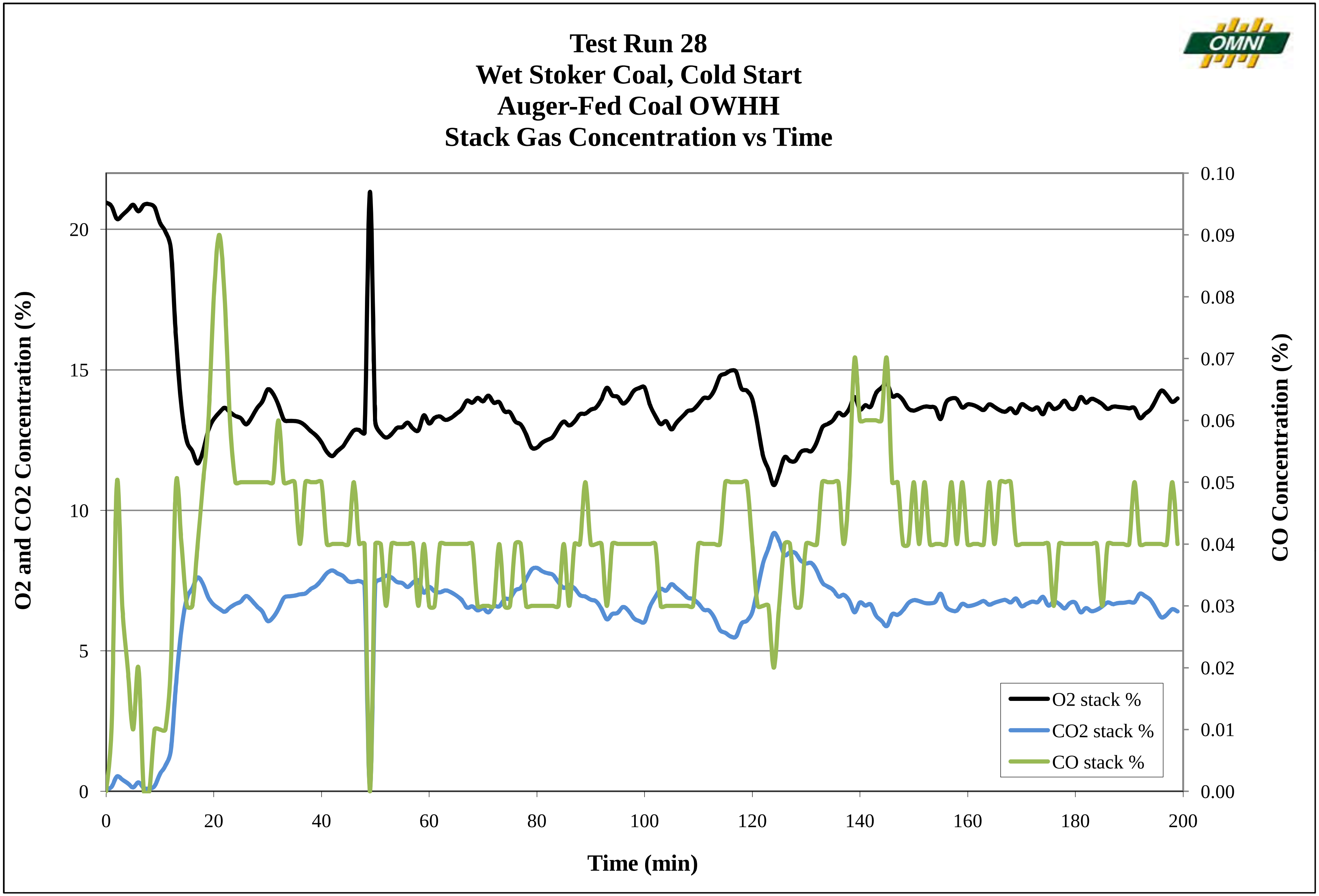

Test Run 25
Spruce High Burn
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
VOC ppmv
Nox ppmv
SO2 ppmv
0
200
400
600
800
1000
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
0
20
40
60
80
100


Test Run 26
Wet Stoker Coal Low Burn
Non-Qualified OWHH
Stack Gas Concentration vs Time
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
0
20
40
60
80
100
120

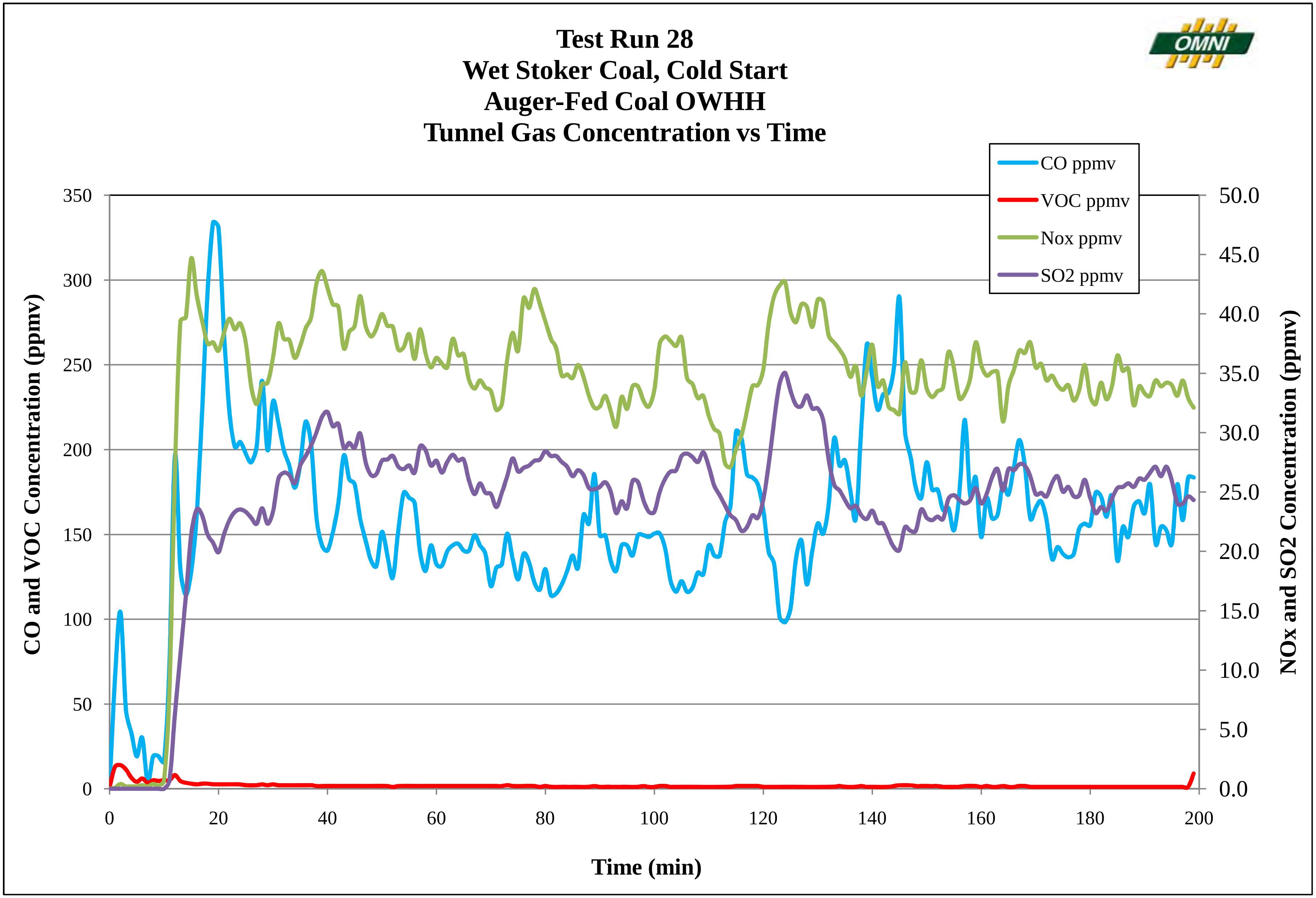

Test Run 26
Wet Stoker Coal Low Burn
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
OMNI
VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
VOC ppmv
Nox ppmv
SO2 ppmv
0
200
400
600
800
1000
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0
20
40
60
80
100
120

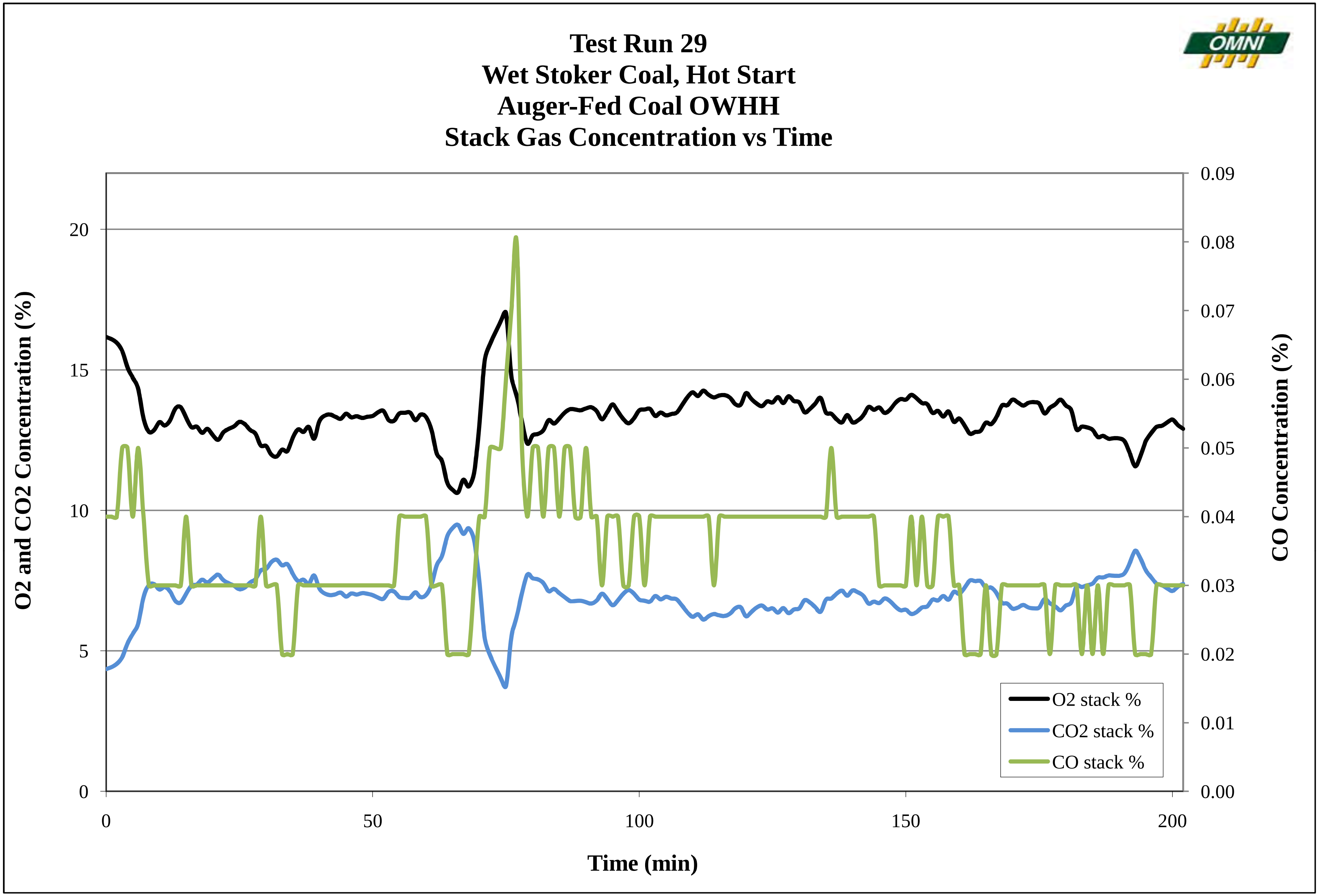


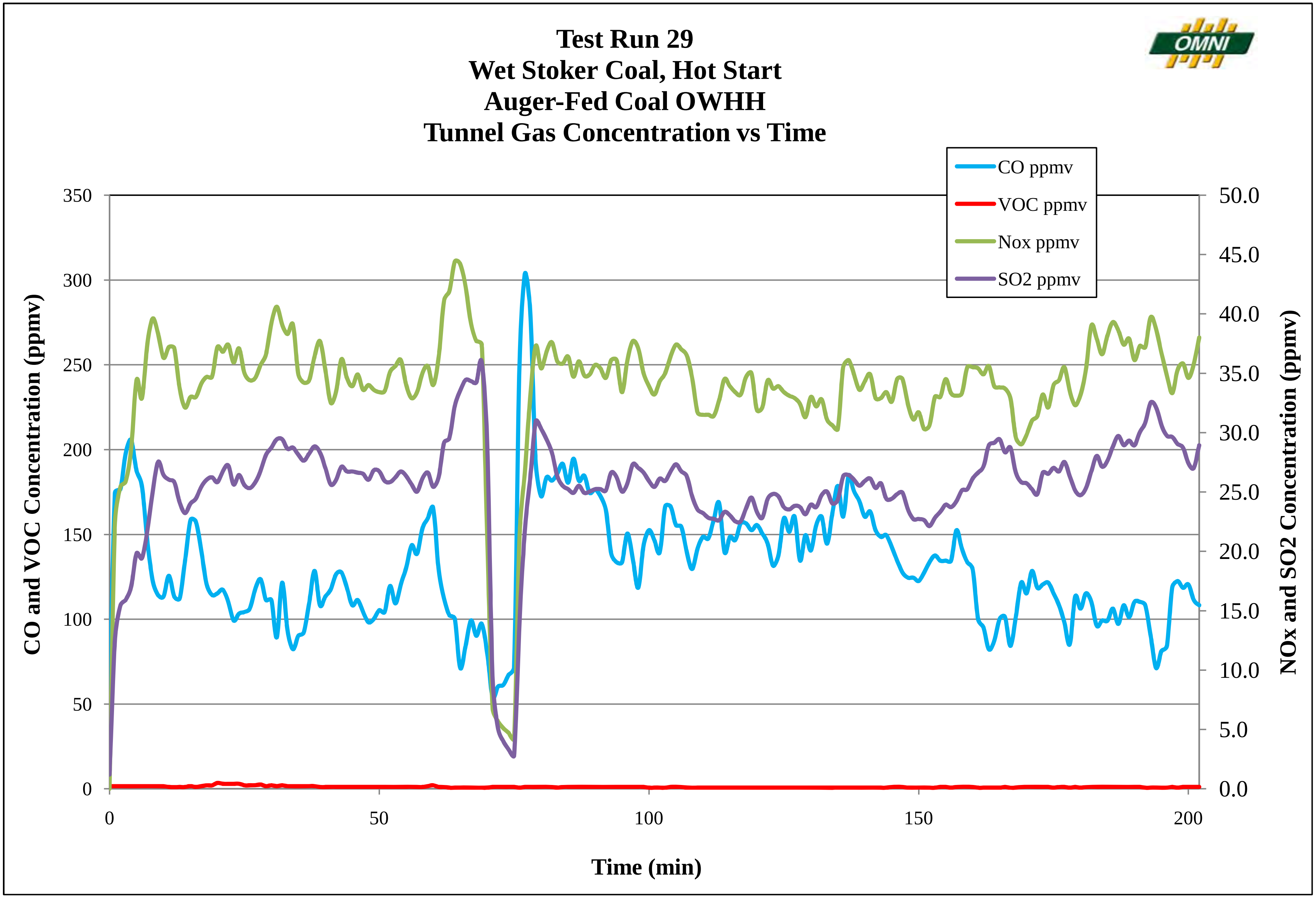
Test Run 27
Wet Stoker Coal, Low Burn, Cold Start
Non-Qualified OWHH with Retrofit Catalyst
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
200
400
600
800
1000
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
20
40
60
80
100
120
140
160
180

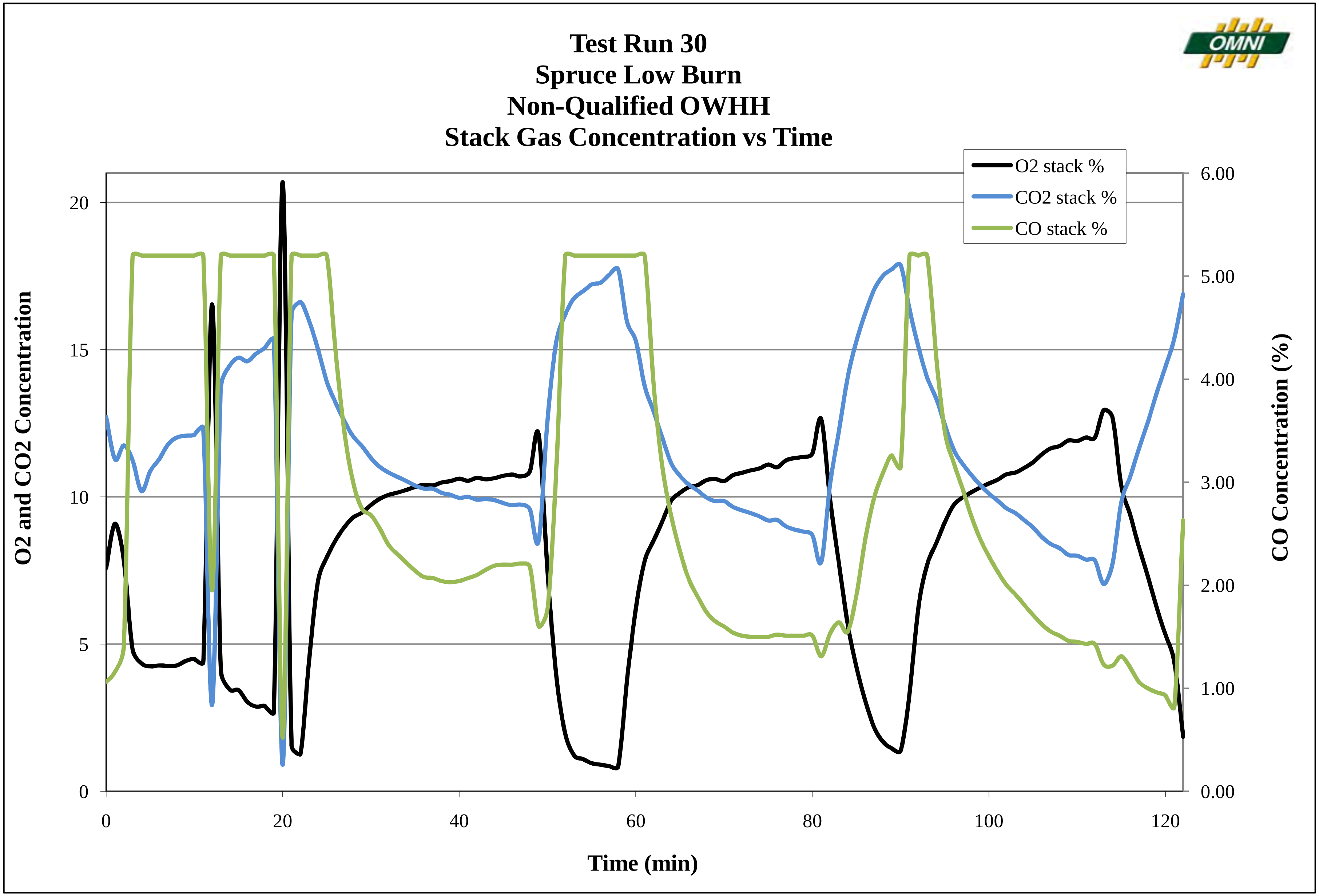


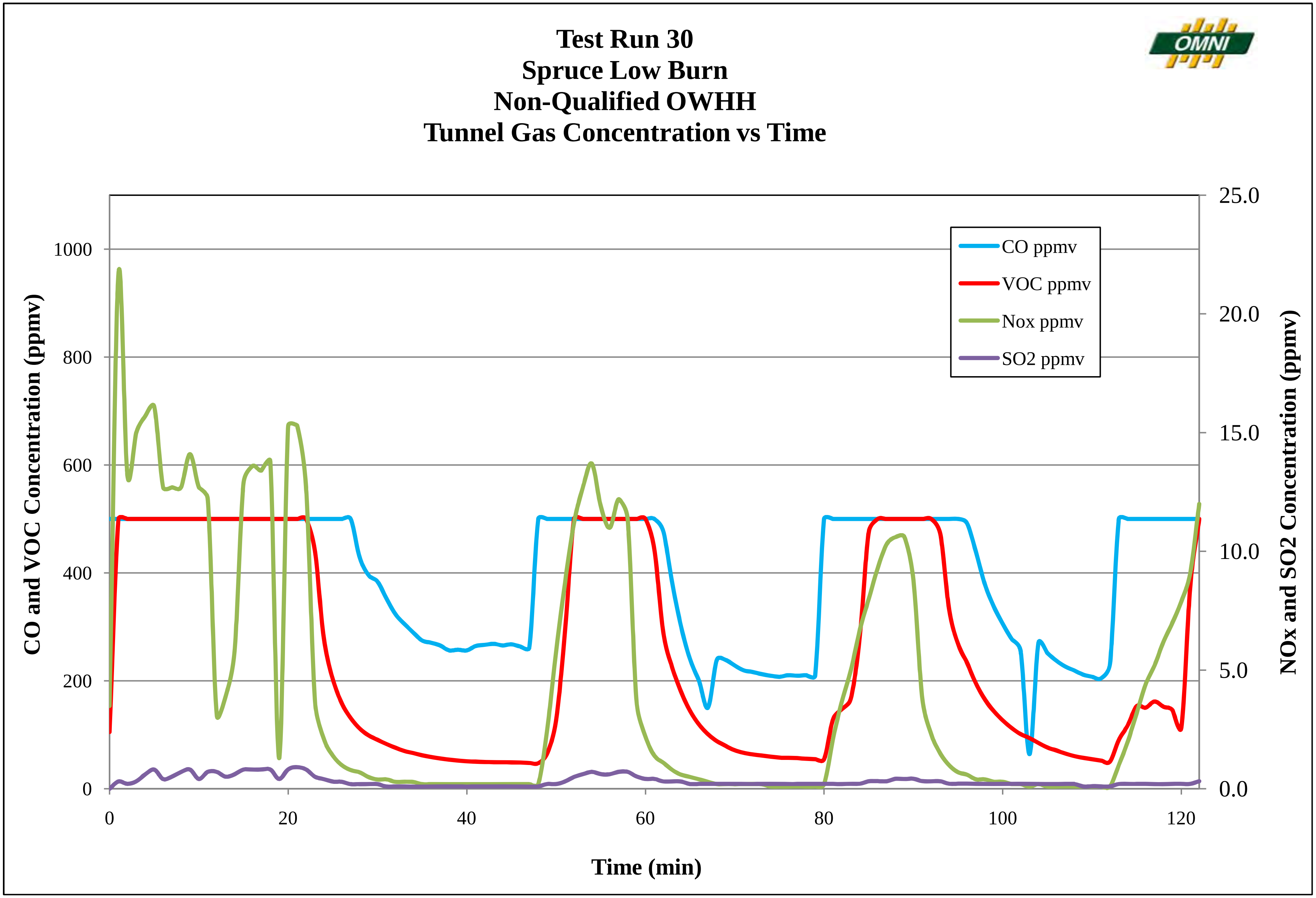
Test Run 28
Wet Stoker Coal, Cold Start
Auger-Fed Coal OWHH
Stack Gas Concentration vs Time
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0
20
40
60
80
100
120
140
160
180
200
O2 stack %
CO2 stack %
CO stack %

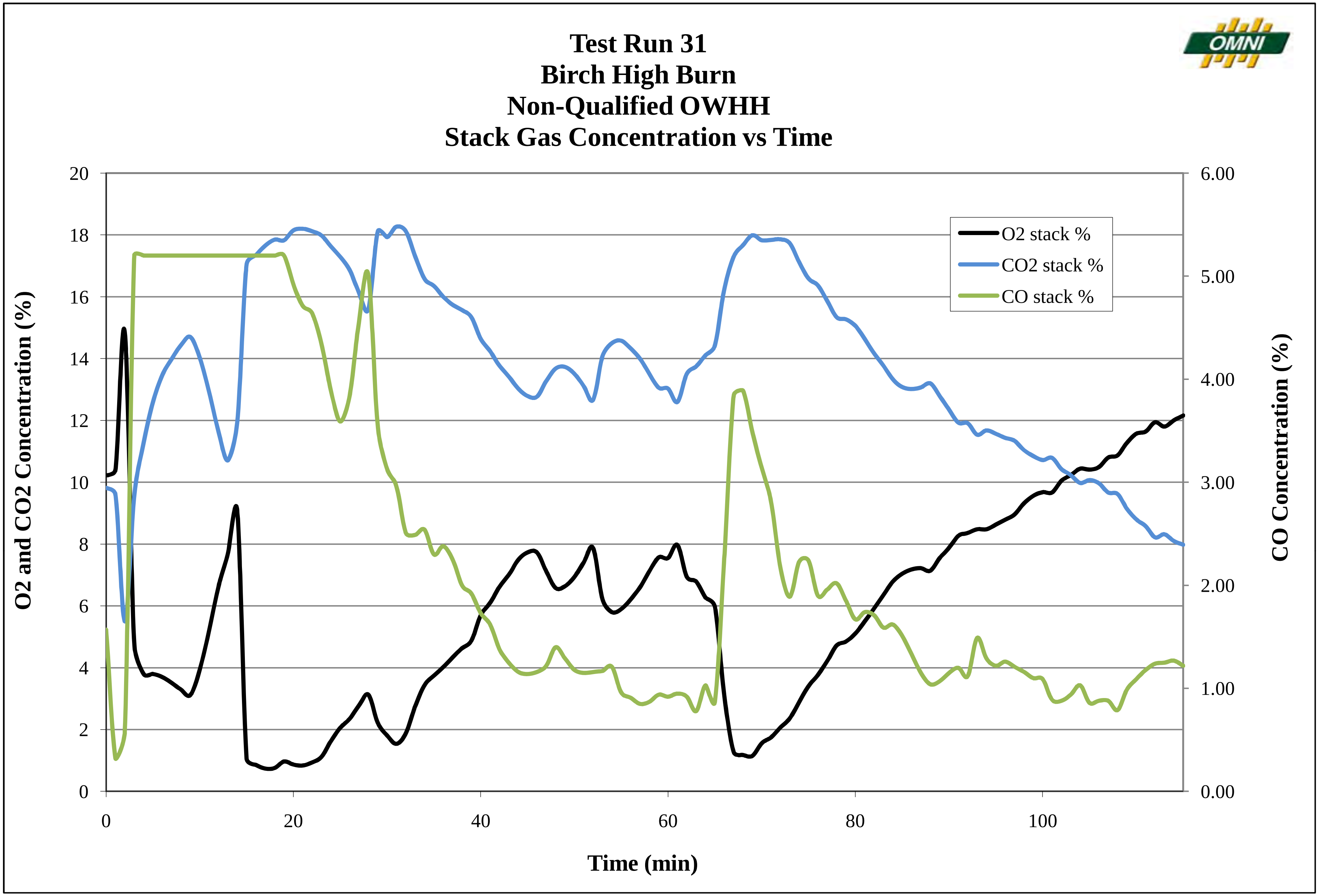

Test Run 28
Wet Stoker Coal, Cold Start
Auger-Fed Coal OWHH
Tunnel Gas Concentration vs Time
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
50
100
150
200
250
300
350
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
0
20
40
60
80
100
120
140
160
180
200


Test Run 29
Wet Stoker Coal, Hot Start
Auger-Fed Coal OWHH
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
5
10
15
20
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0
50
100
150
200

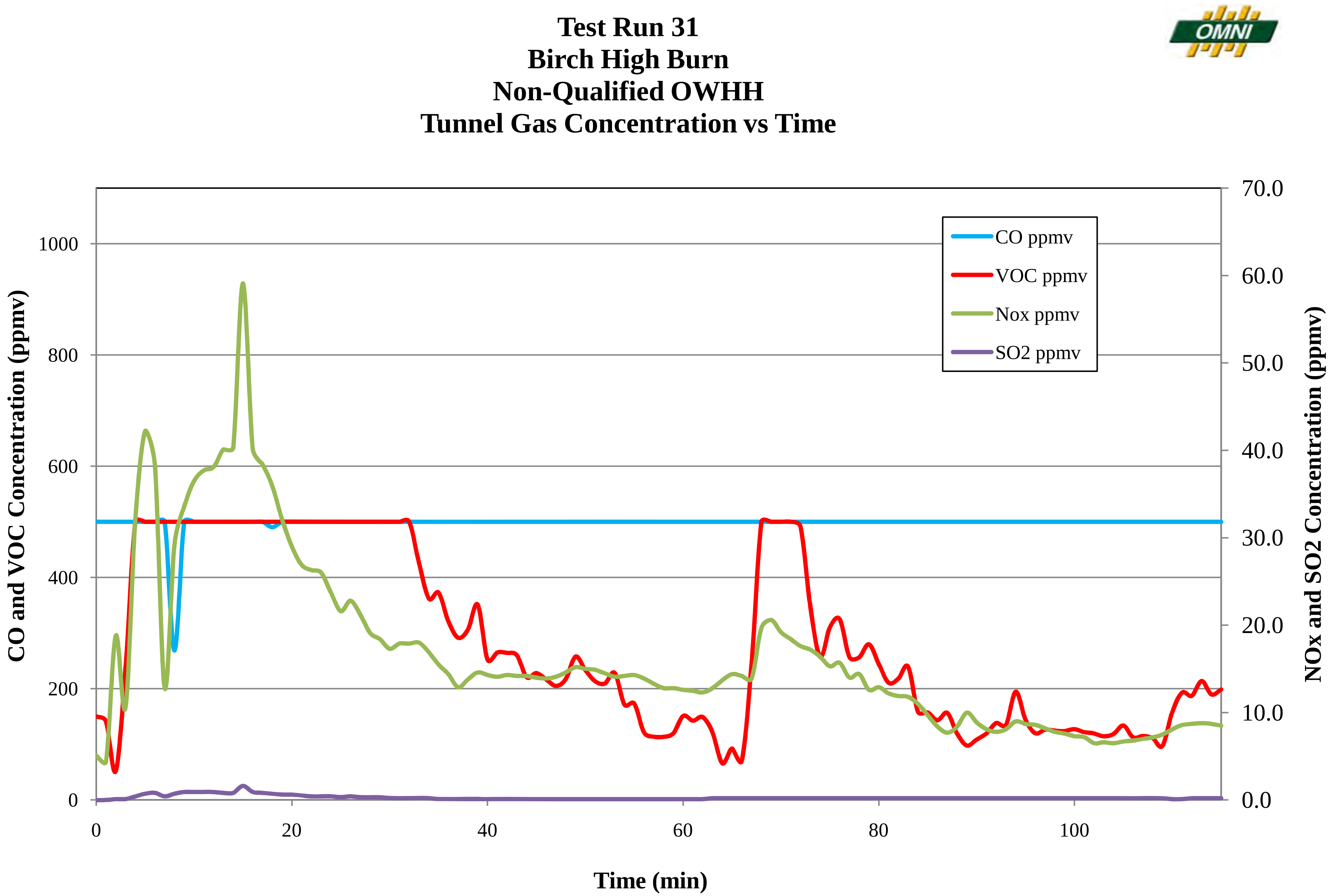

Test Run 29
Wet Stoker Coal, Hot Start
Auger-Fed Coal OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
50
100
150
200
250
300
350
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0

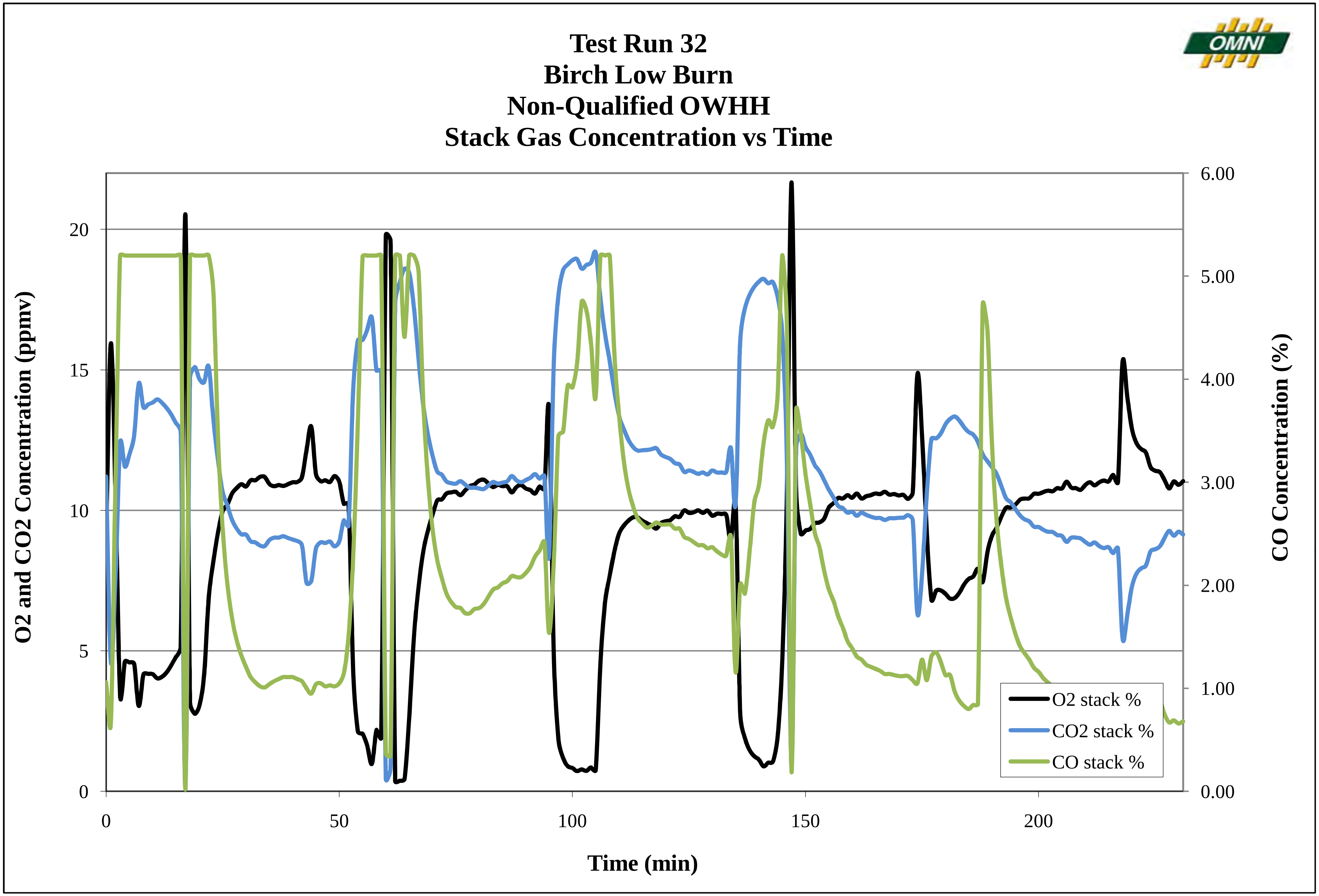

Test Run 30
Spruce Low Burn
Non-Qualified OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
20
40
60
80
100
120

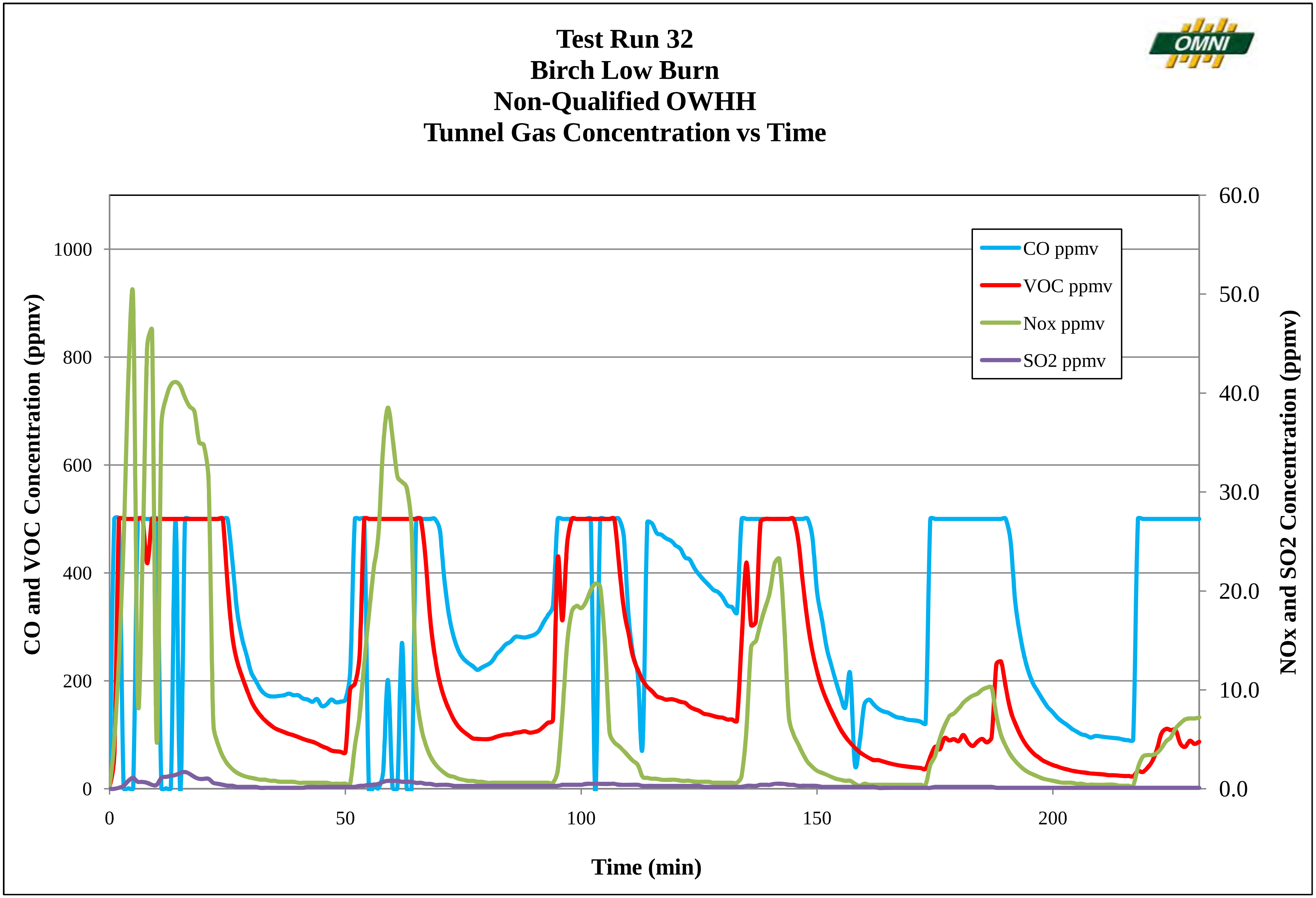

Test Run 30
Spruce Low Burn
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
200
400
600
800
1000
0.0
5.0
10.0
15.0
20.0
25.0
0
20
40
60
80
100
120

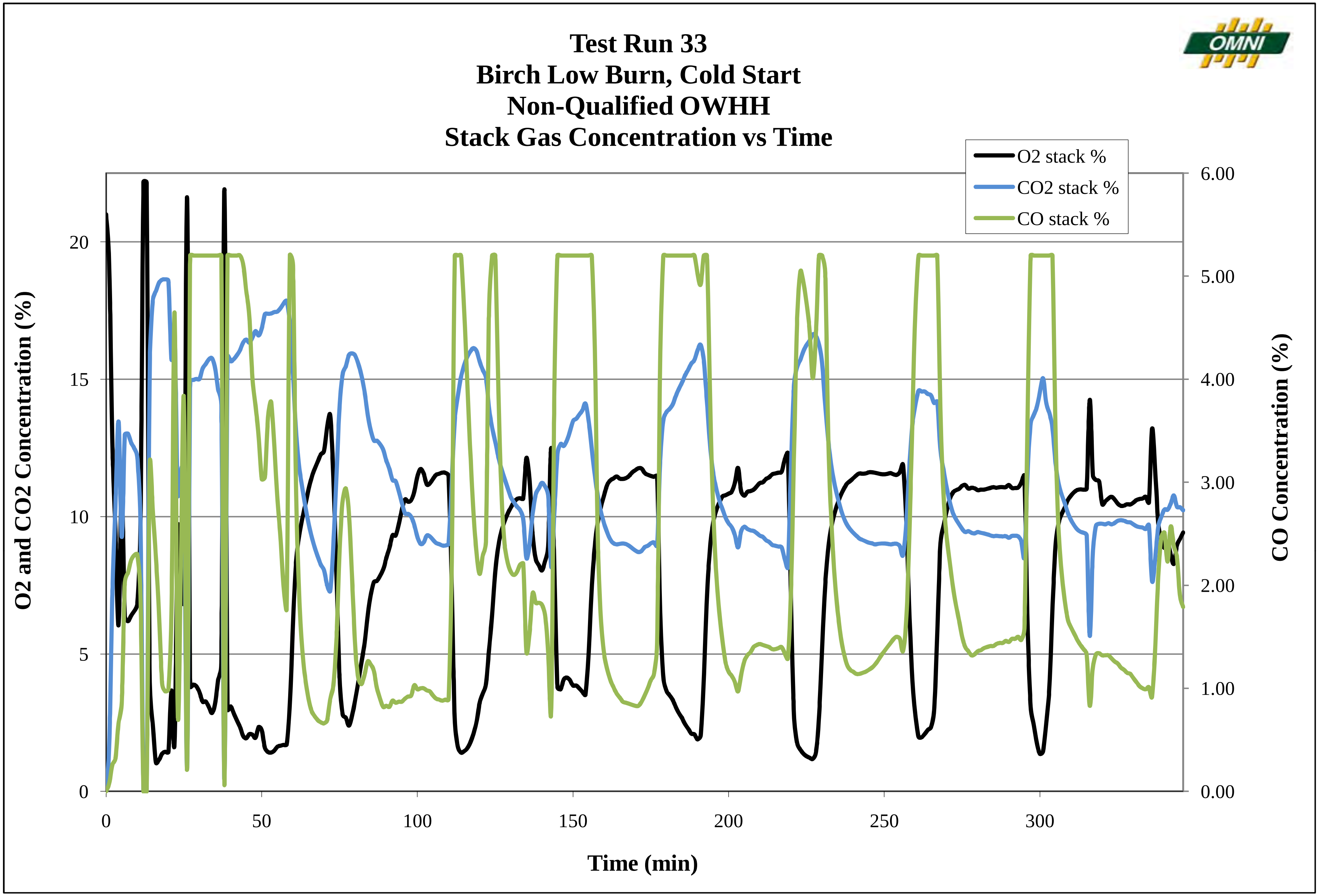


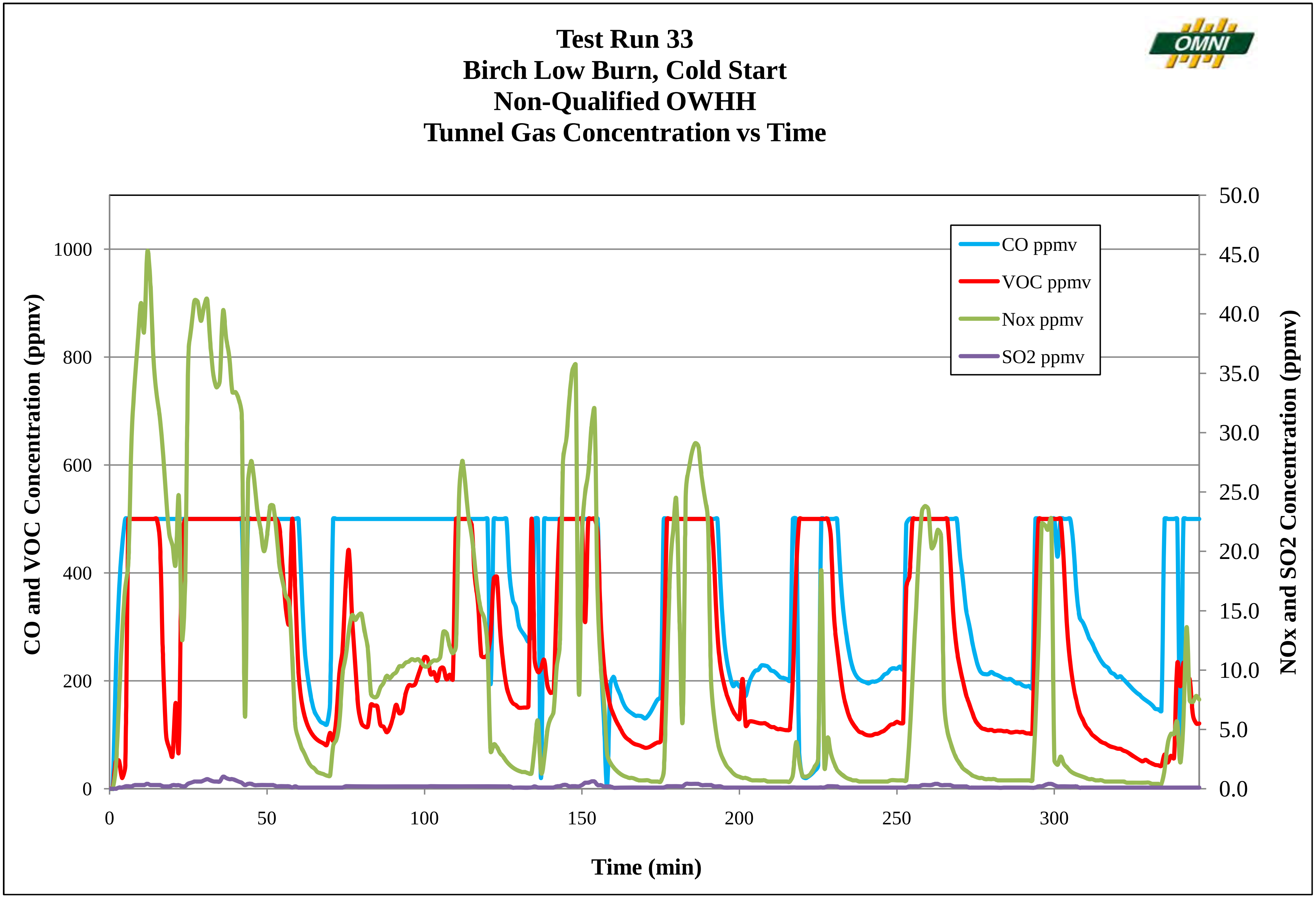
Test Run 31
Birch High Burn
Non-Qualified OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
2
4
6
8
10
12
14
16
18
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
20
40
60
80
100

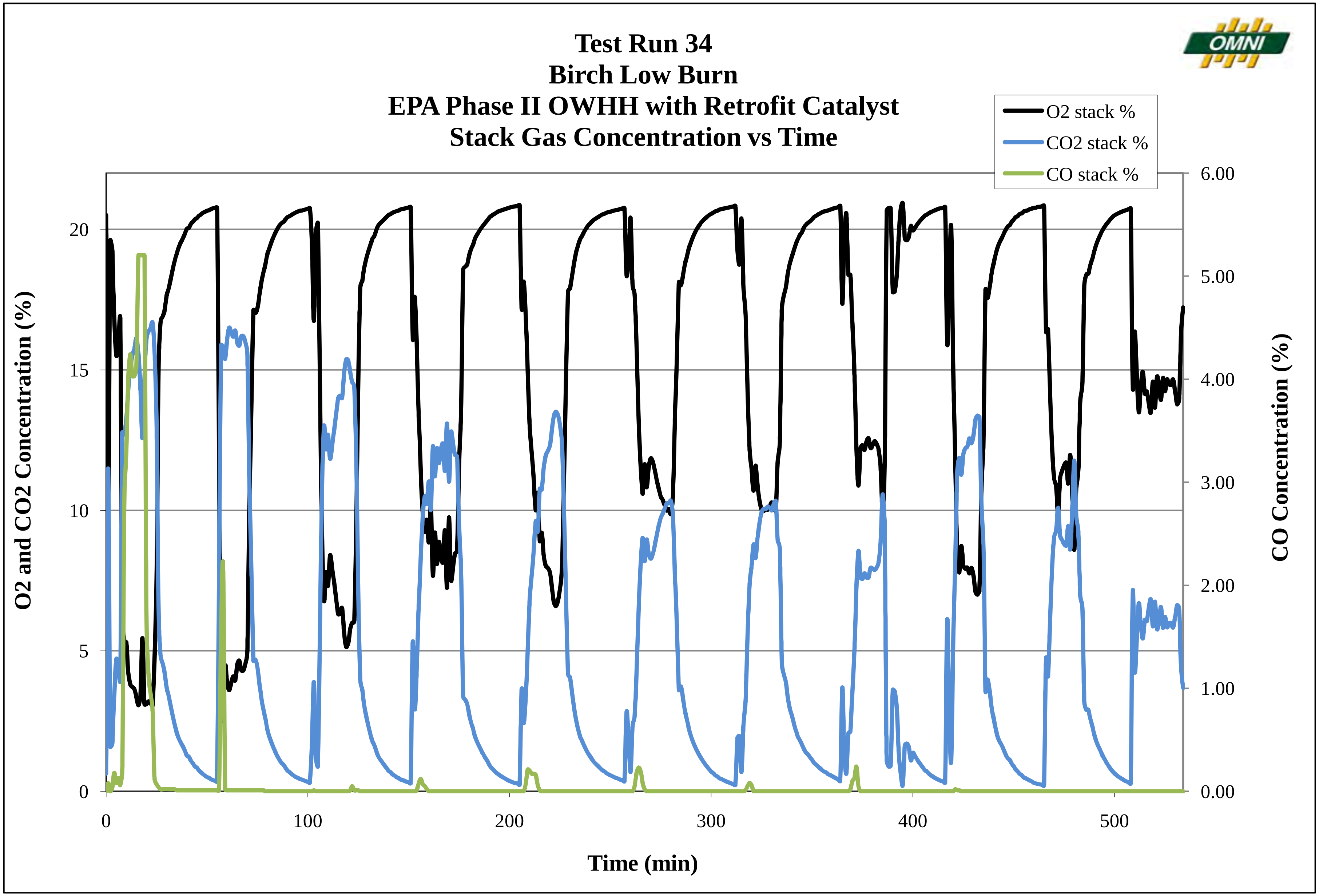

Test Run 31
Birch High Burn
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
200
400
600
800
1000
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
0
20
40
60
80
100

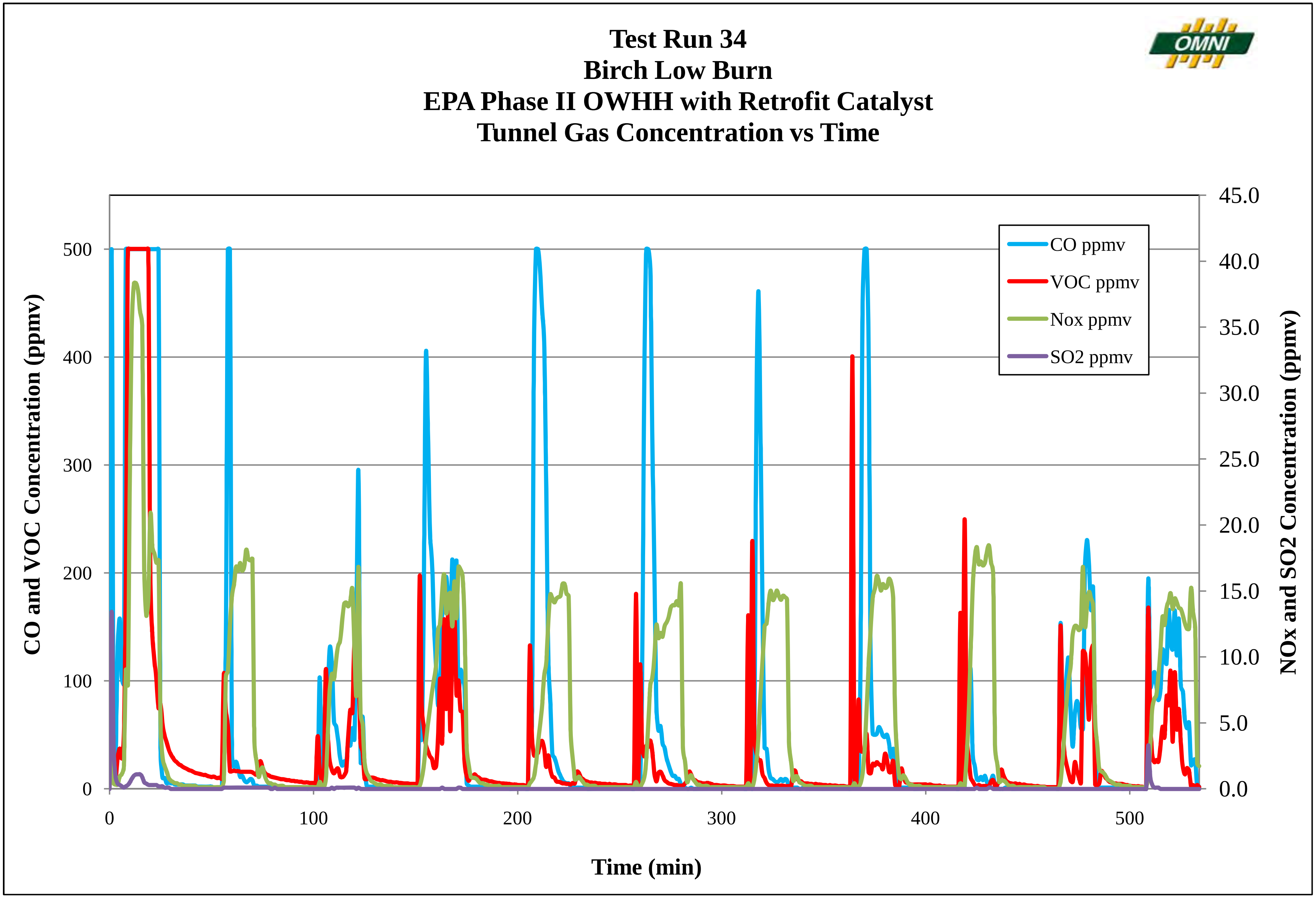

Test Run 32
Birch Low Burn
Non-Qualified OWHH
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (ppmv)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200
O2 stack %
CO2 stack %
CO stack %

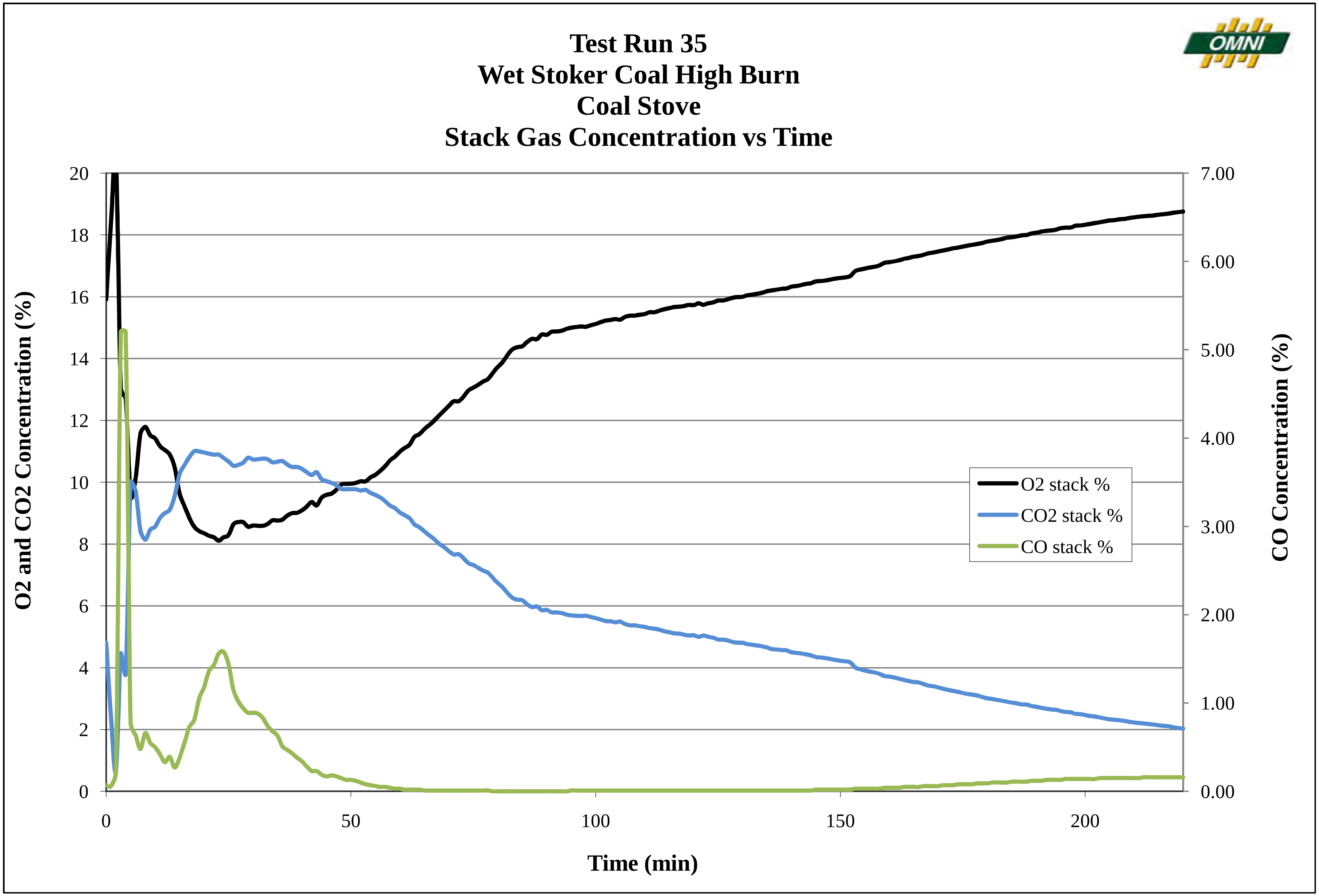

Test Run 32
Birch Low Burn
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
200
400
600
800
1000
0.0
10.0
20.0
30.0
40.0
50.0
60.0
0
50
100
150
200

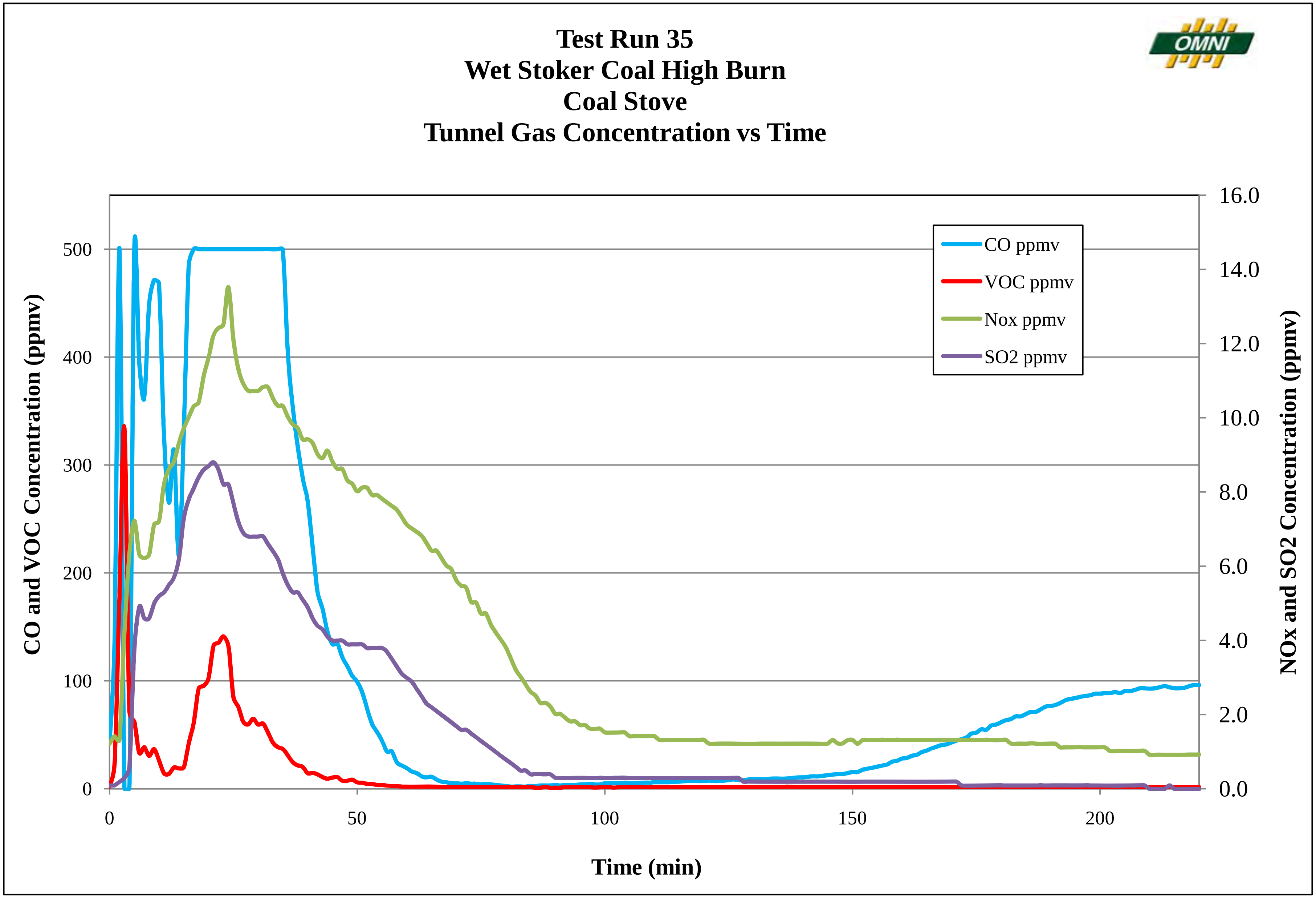

Test Run 33
Birch Low Burn, Cold Start
Non-Qualified OWHH
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200
250
300

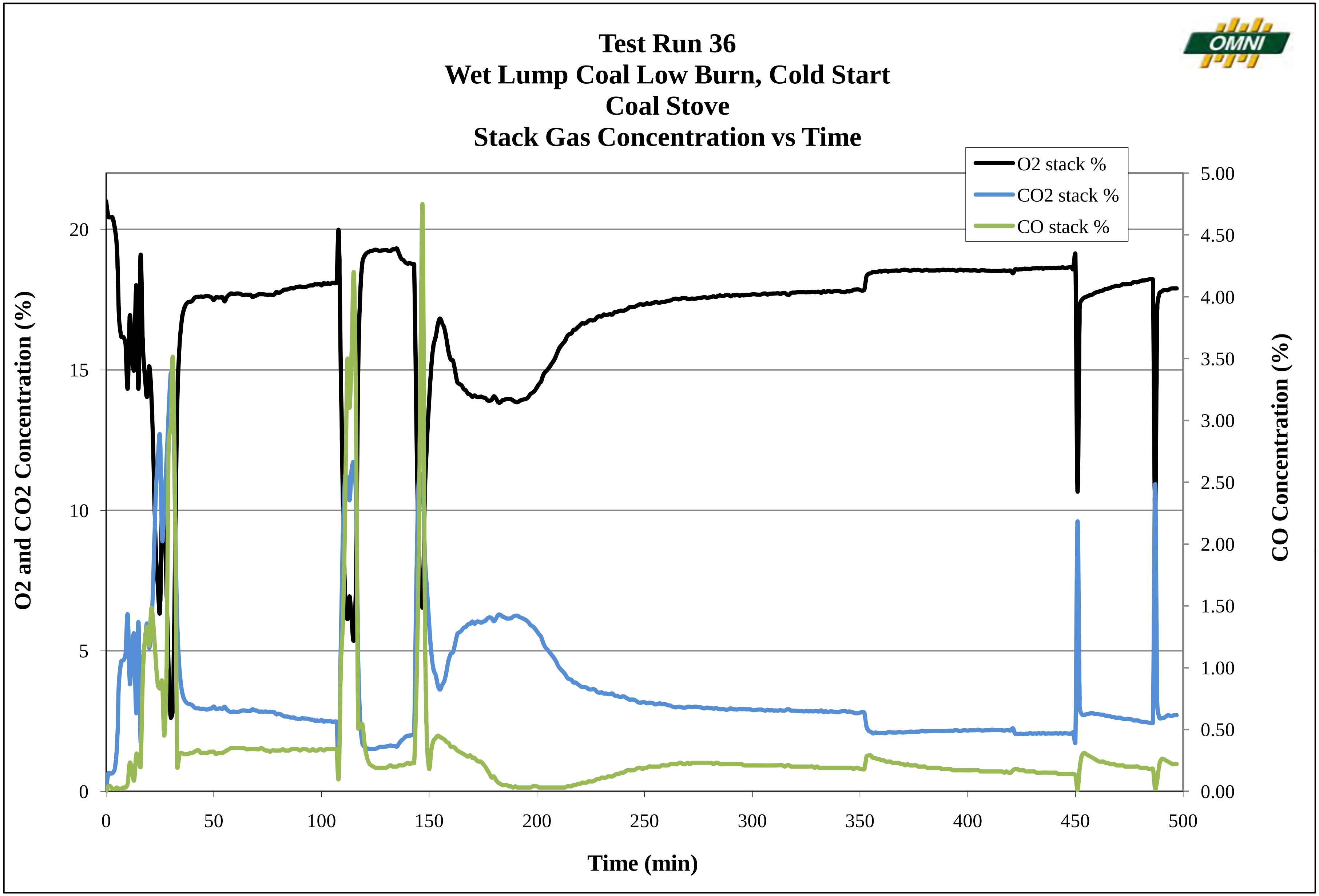

Test Run 33
Birch Low Burn, Cold Start
Non-Qualified OWHH
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
200
400
600
800
1000
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
0
50
100
150
200
250
300

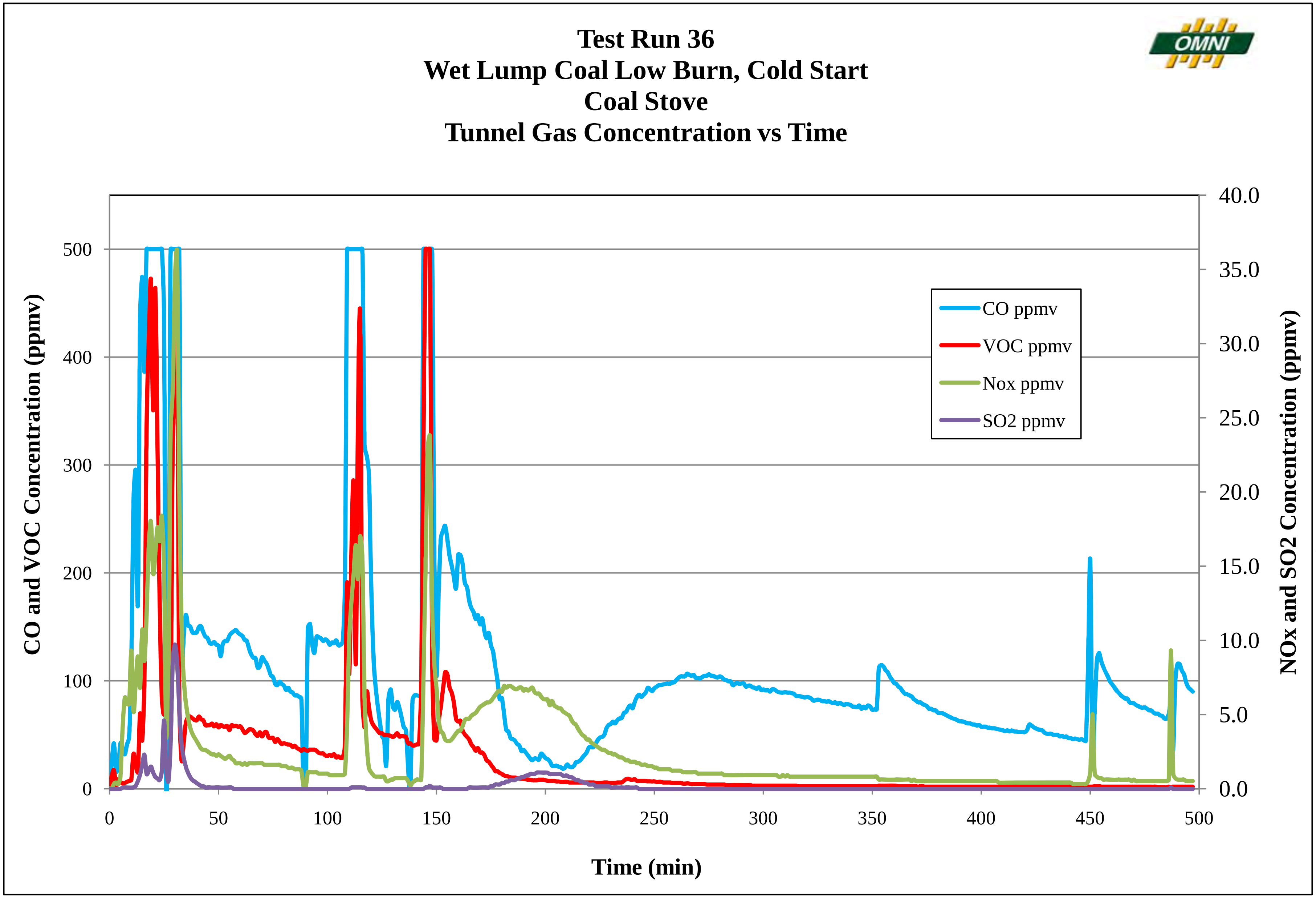

Test Run 34
Birch Low Burn
EPA Phase II OWHH with Retrofit Catalyst
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
100
200
300
400
500

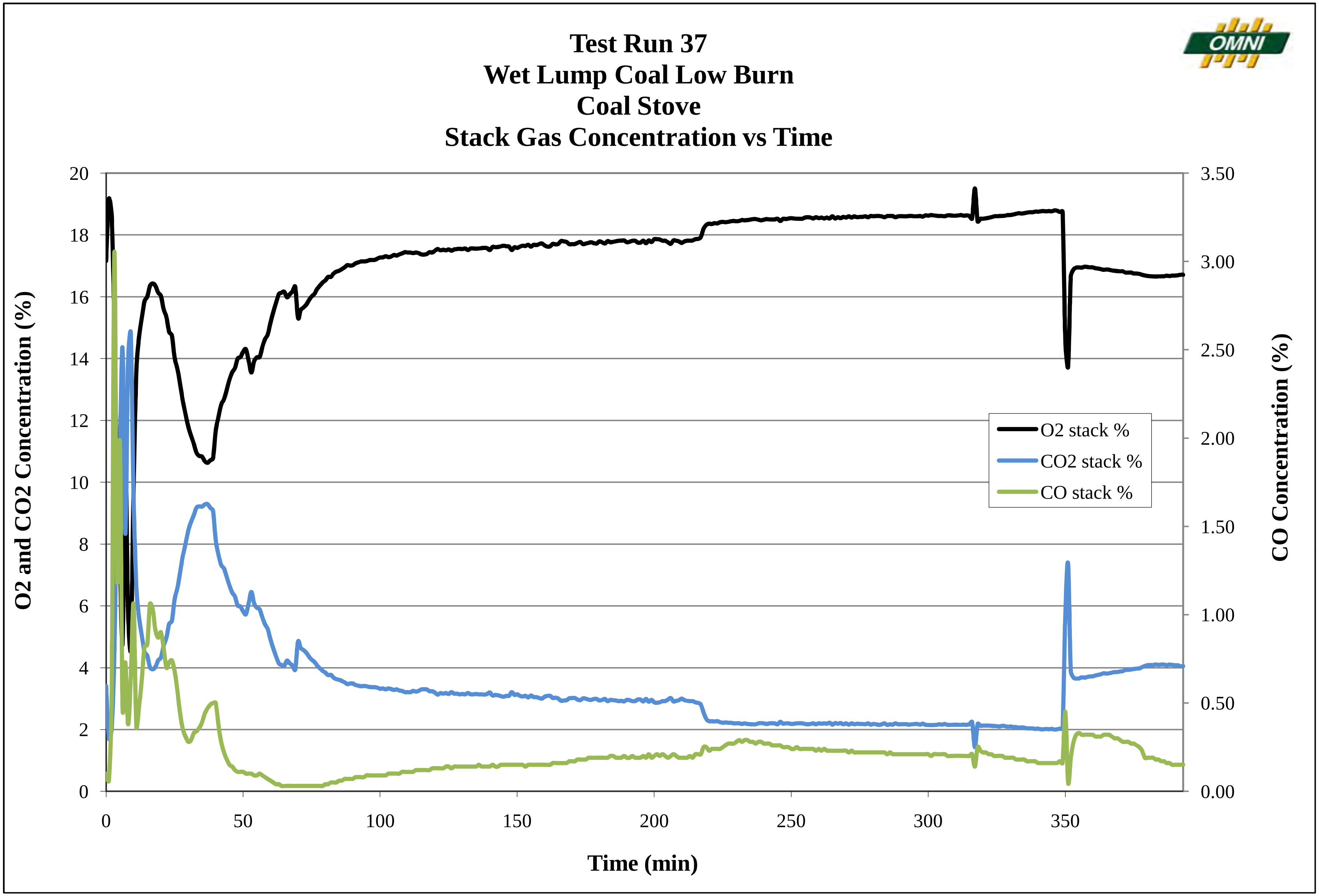

Test Run 34
Birch Low Burn
EPA Phase II OWHH with Retrofit Catalyst
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0

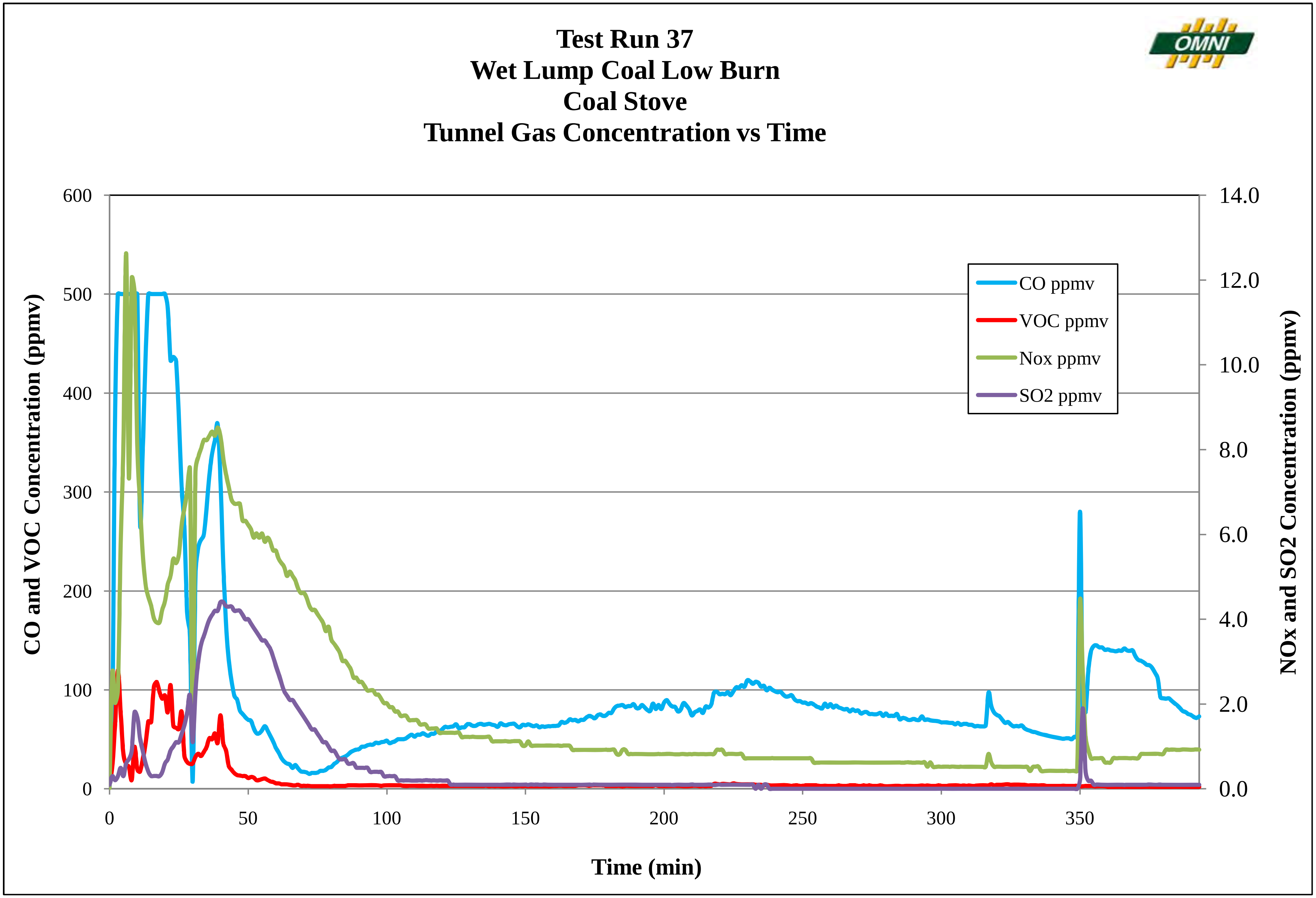

Test Run 35
Wet Stoker Coal High Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
20
18
16
14
12
10
8
6
4
2
0
CO Concentration (%)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
50
100
150
200
Time (min)
O2 stack %
CO2 stack %
CO stack %

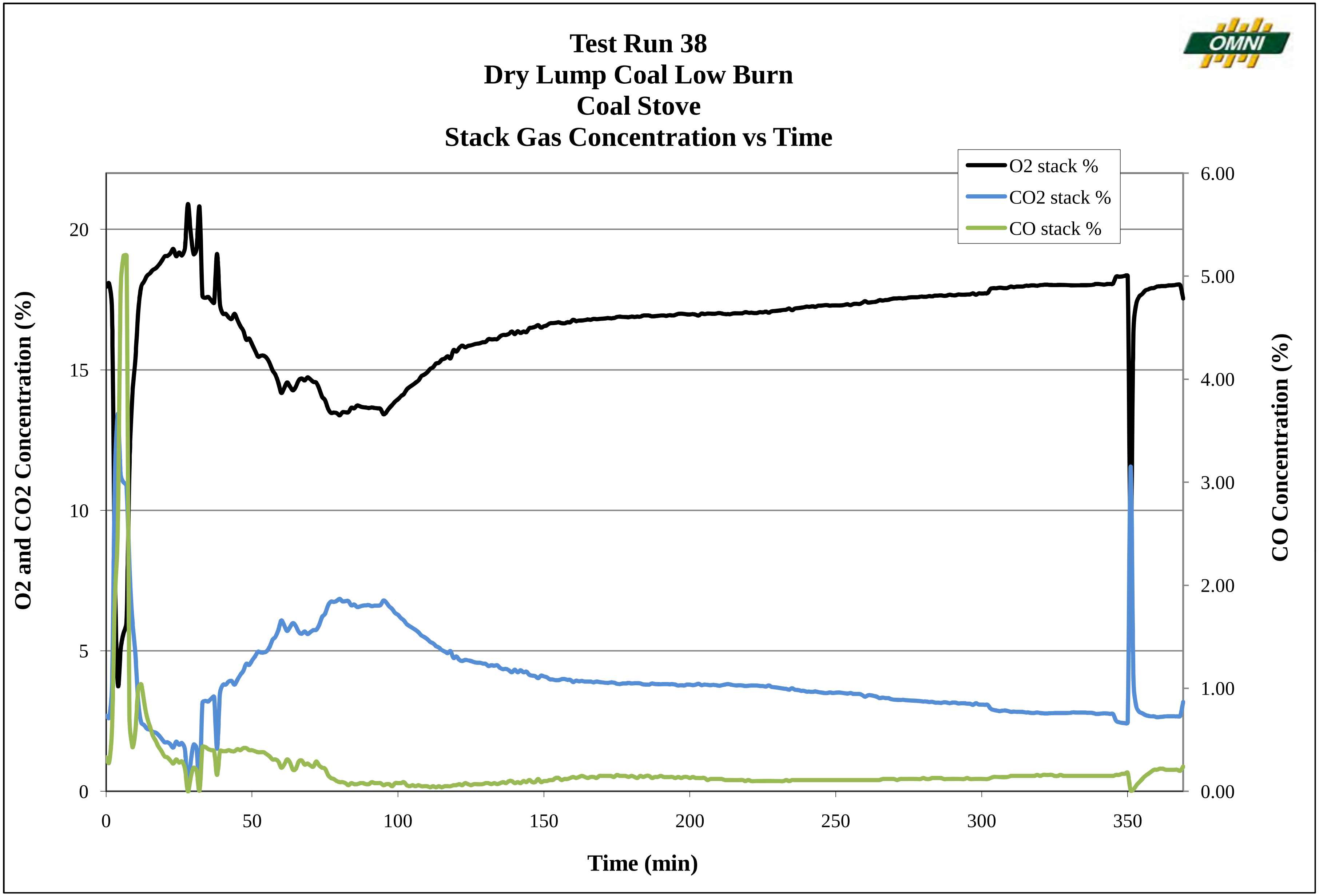

Test Run 35
Wet Stoker Coal High Burn
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
0
50
100
150
200

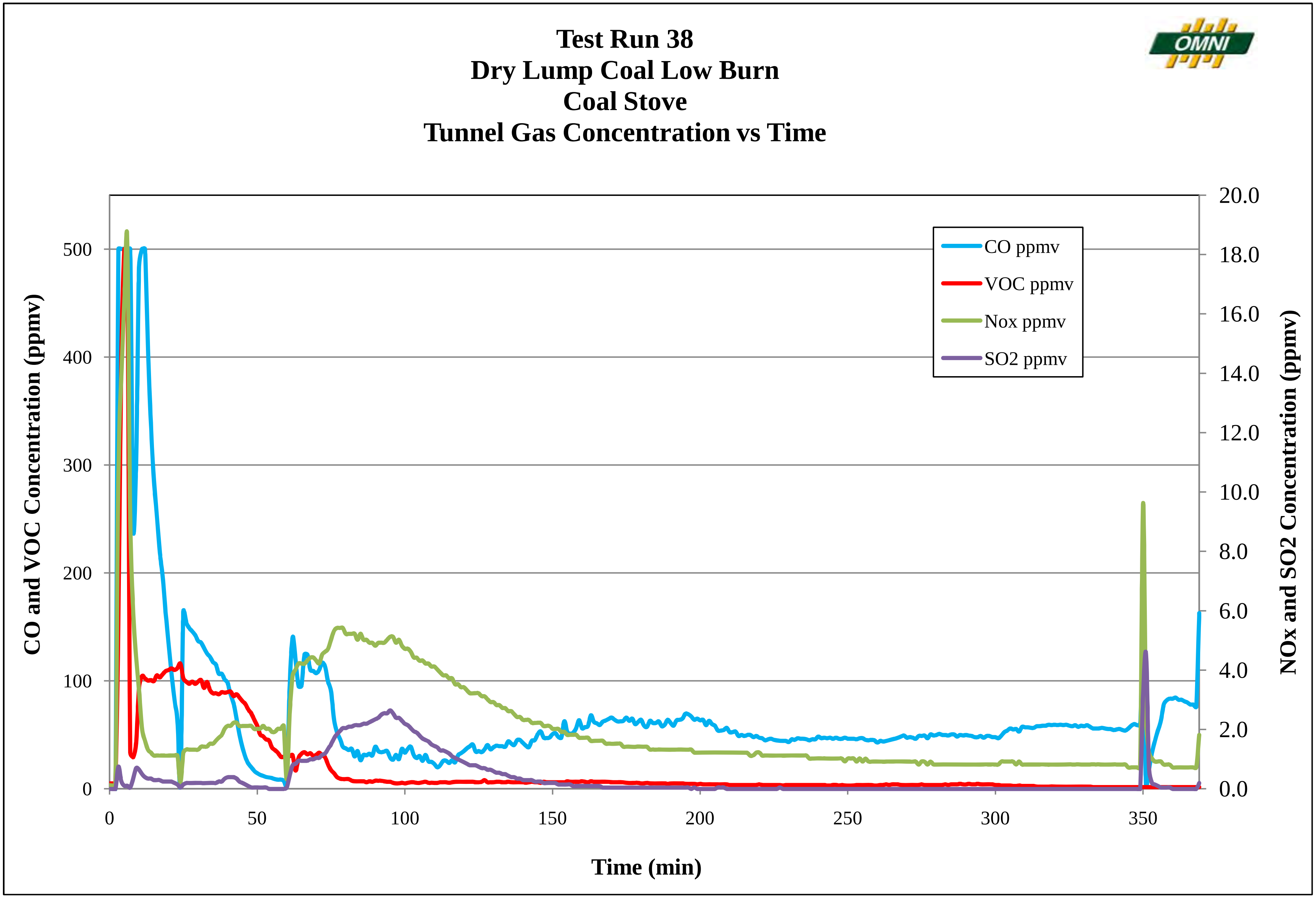

Test Run 36
Wet Lump Coal Low Burn, Cold Start
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
0
50
100
150
200
250
300
350
400
450
500

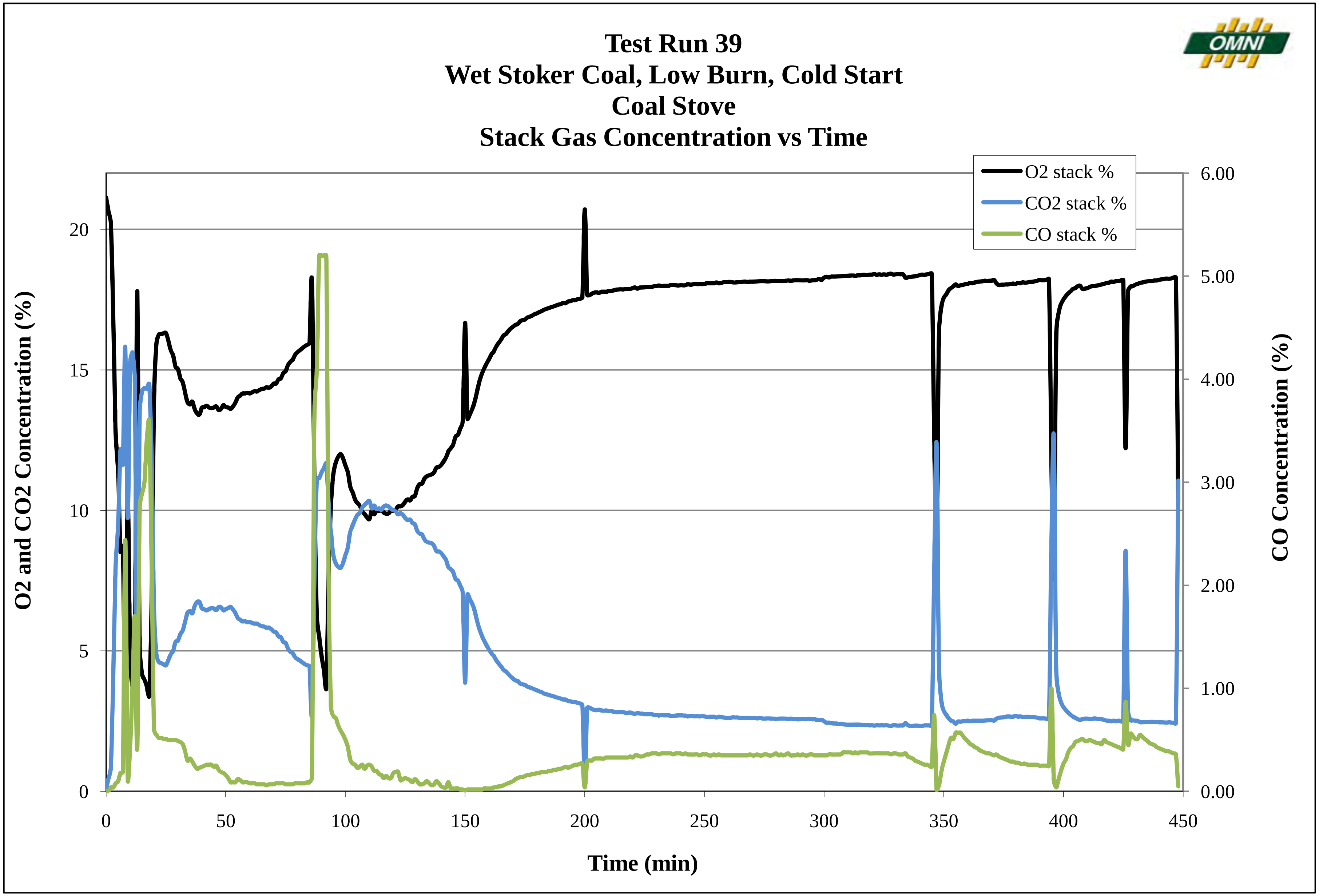

Test Run 36
Wet Lump Coal Low Burn, Cold Start
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
0
50
100
150
200
250
300
350
400
450
500

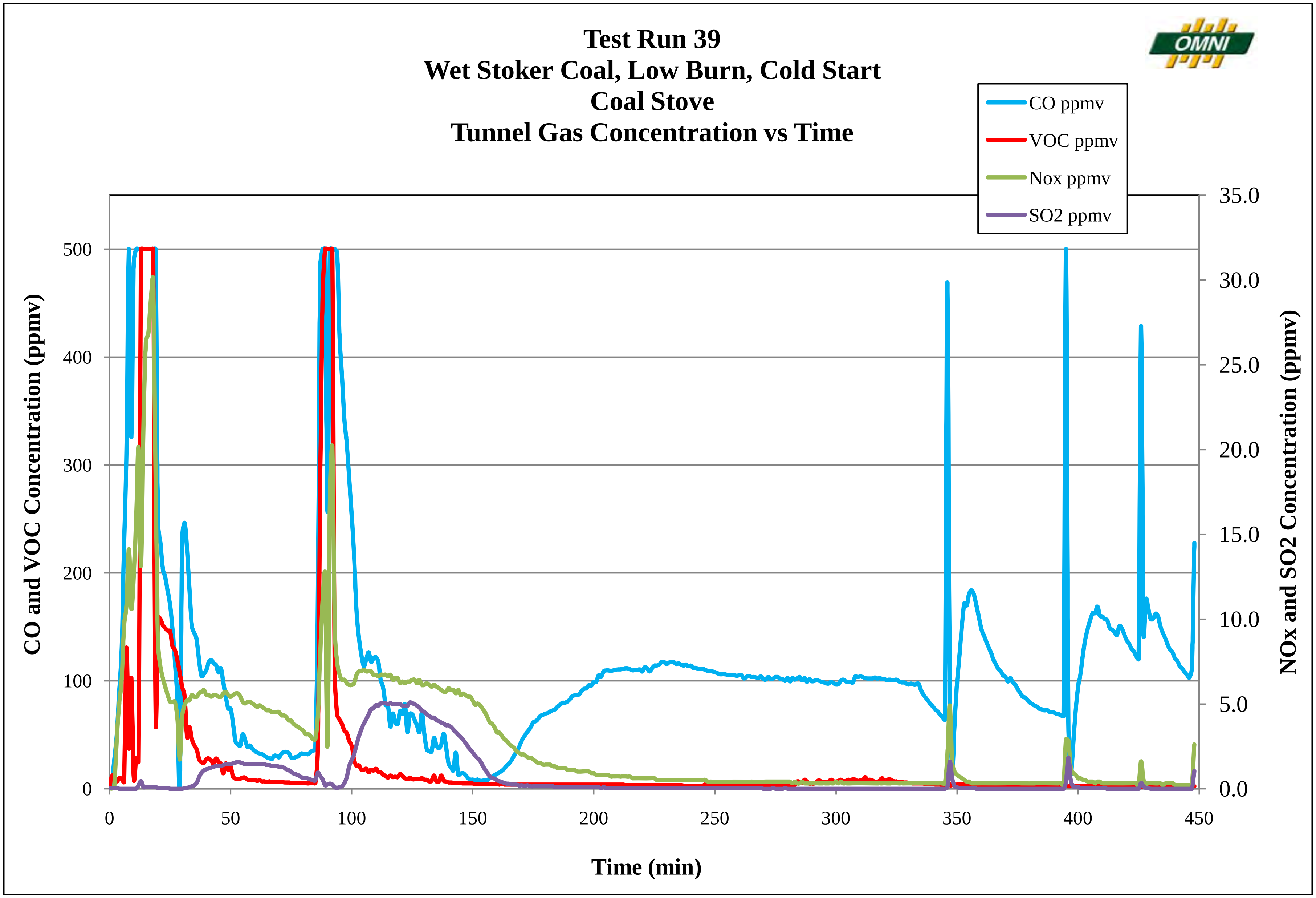

Test Run 37
Wet Lump Coal Low Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
0
50
100
150
200
250
300
350

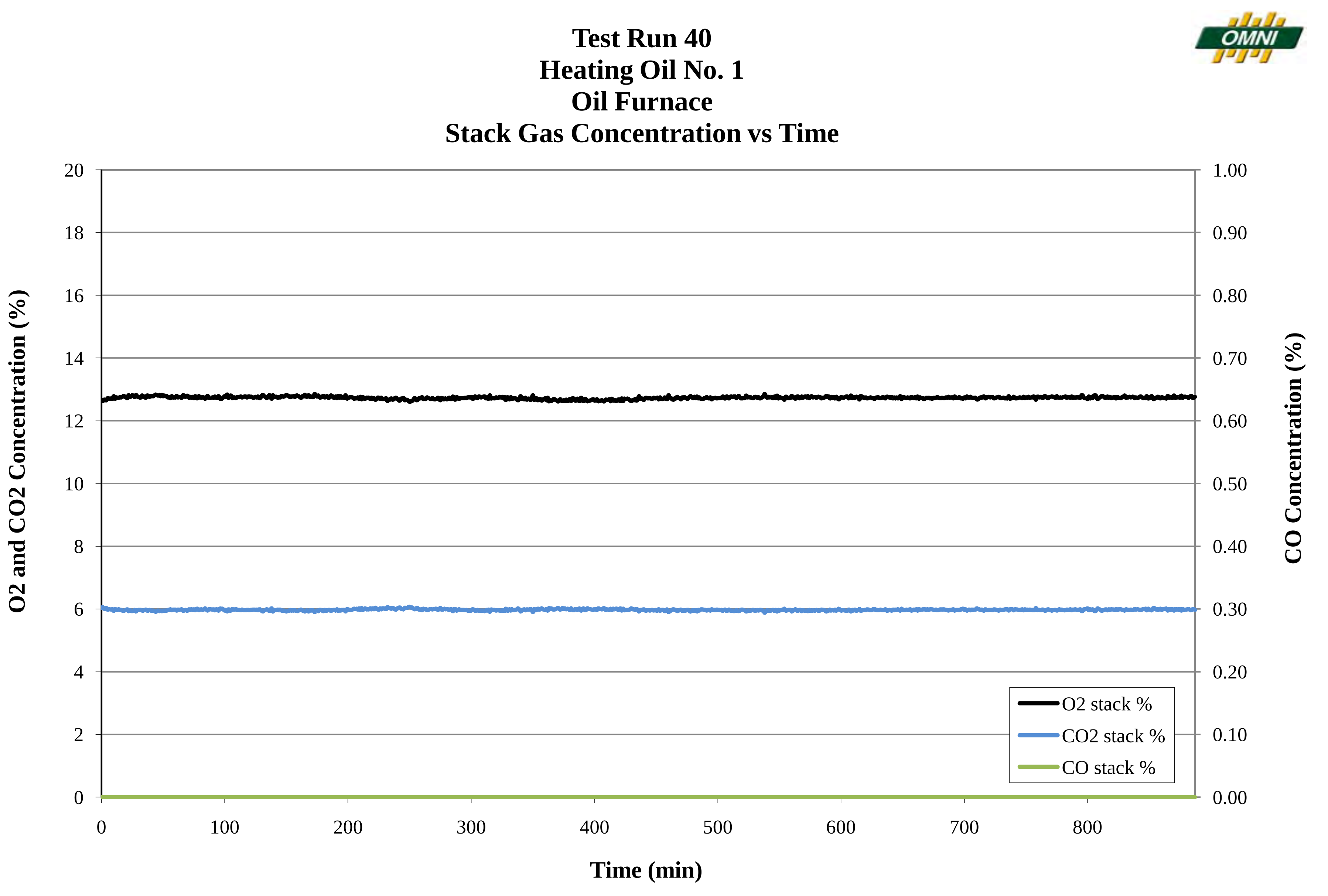

Test Run 37
Wet Lump Coal Low Burn
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
600
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0
50
100
150
200
250
300
350

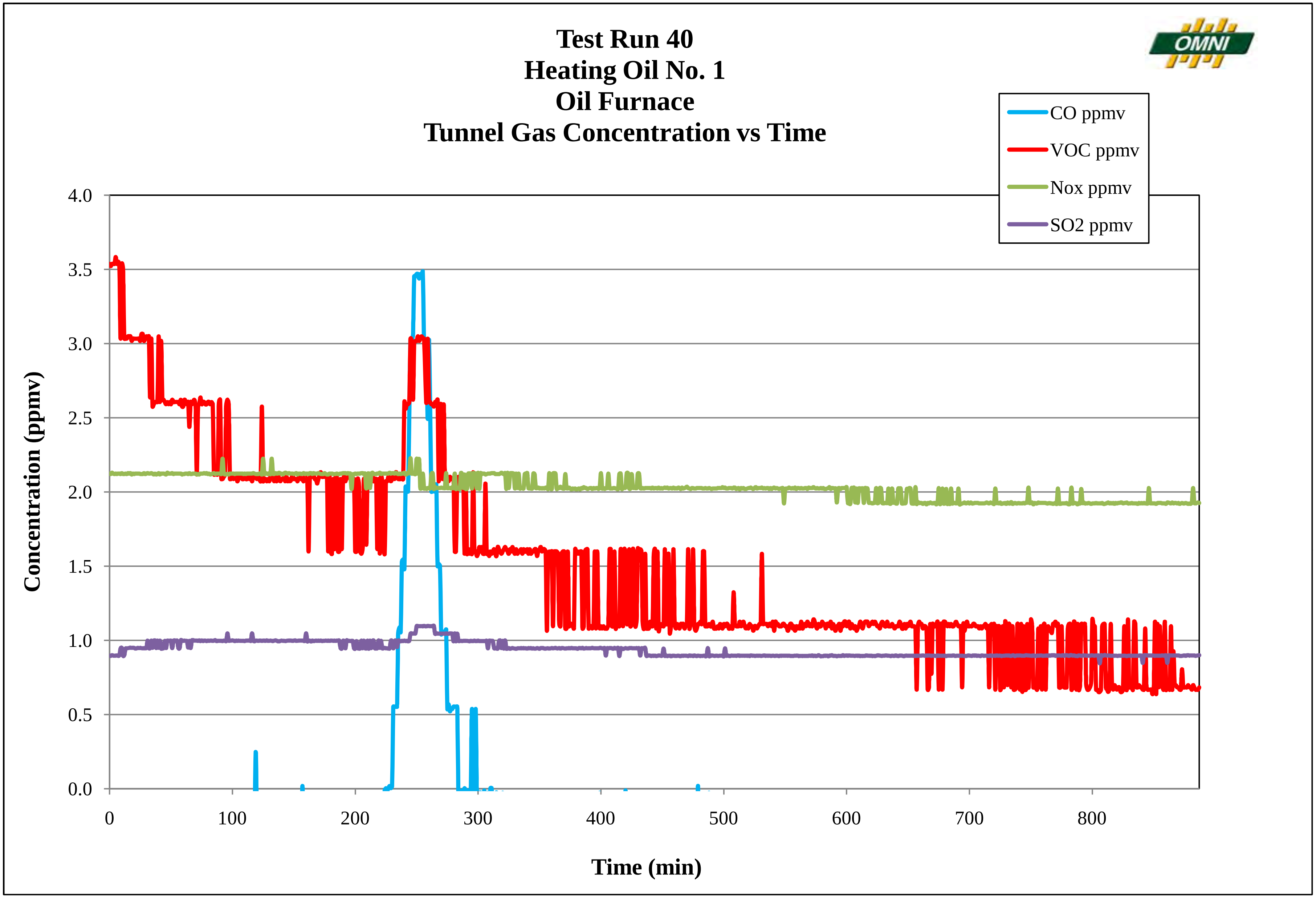

Test Run 38
Dry Lump Coal Low Burn
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200
250
300
350

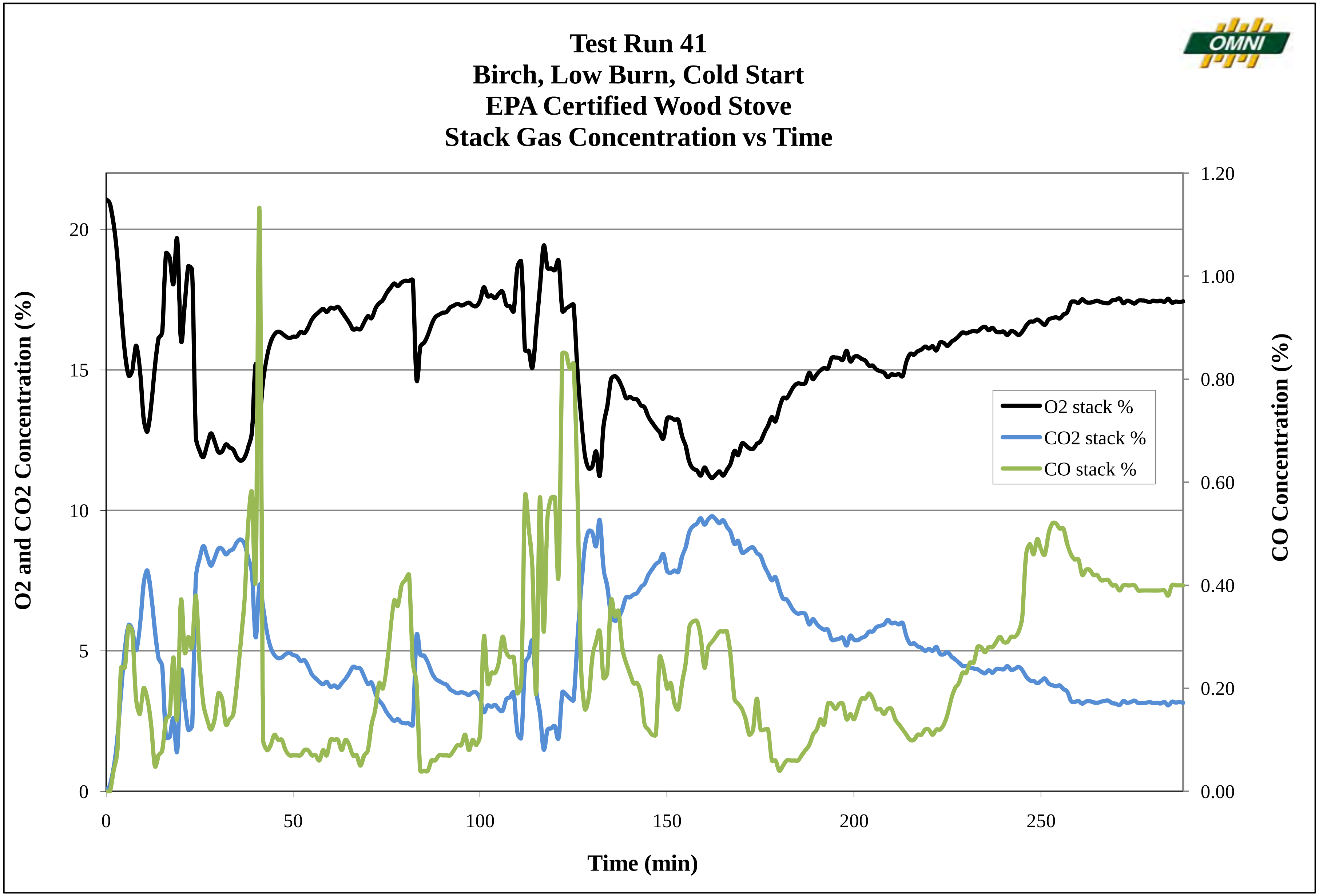

Test Run 38
Dry Lump Coal Low Burn
Coal Stove
Tunnel Gas Concentration vs Time
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
0
50
100
150
200
250
300
350


Test Run 39
Wet Stoker Coal, Low Burn, Cold Start
Coal Stove
Stack Gas Concentration vs Time
OMNI
O2 stack %
CO2 stack %
CO stack %
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
0
5
10
15
20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0
50
100
150
200
250
300
350
400
450

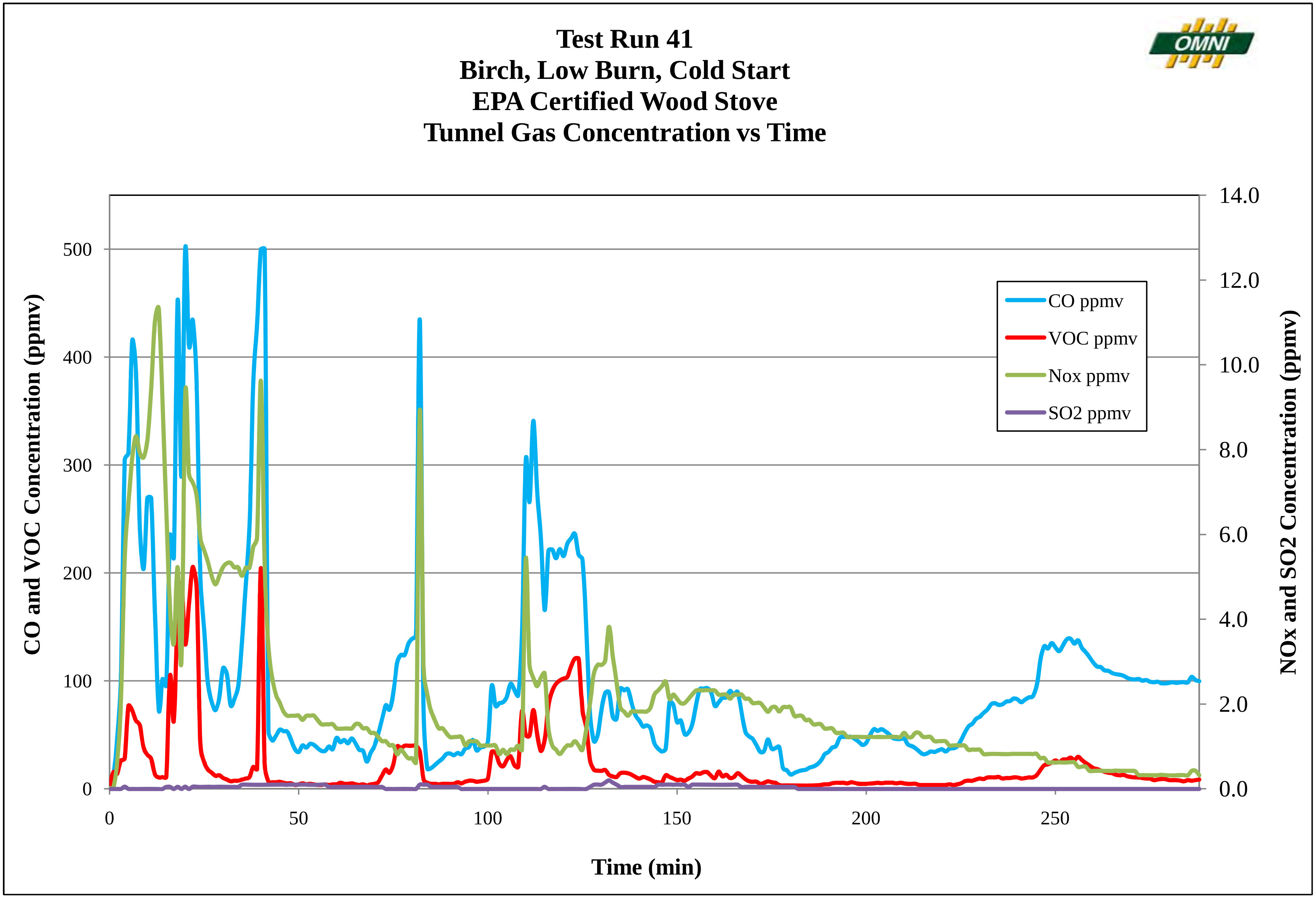

Test Run 39
Wet Stoker Coal, Low Burn, Cold Start
Coal Stove
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
0
100
200
300
400
500
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
0
50
100
150
200
250
300
350
400
450


Test Run 40
Heating Oil No. 1
Oil Furnace
Stack Gas Concentration vs Time
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
2
4
6
8
10
12
14
16
18
20
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
0
100
200
300
400
500
600
700
800


Test Run 40
Heating Oil No. 1
Oil Furnace
Tunnel Gas Concentration vs Time
OMNI
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
Concentration (ppmv)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
700
800
Time (min)



Test Run 41
Birch, Low Burn, Cold Start
EPA Certified Wood Stove
Stack Gas Concentration vs Time
OMNI
O2 and CO2 Concentration (%)
CO Concentration (%)
Time (min)
O2 stack %
CO2 stack %
CO stack %
0
5
10
15
20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0
50
100
150
200
250


Test Run 41
Birch, Low Burn, Cold Start
EPA Certified Wood Stove
Tunnel Gas Concentration vs Time
OMNI
CO and VOC Concentration (ppmv)
NOx and SO2 Concentration (ppmv)
Time (min)
CO ppmv
VOC ppmv
Nox ppmv
SO2 ppmv
0
100
200
300
400
500
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0
50
100
150
200
250

Measurement of Space-Heating Emissions

Appendix D

Ammonia Laboratory Results

Appliance:	Pellet Stove	**Burn Rate:**	High	**Run #:**	1
Fuel:	Alaskan Pellets	**Date:**	3/8/2011		

Reporting Units: ◉ Total ug ○ mg/L

Run Information:

	Catch (Total ug)	Volume (L)
Impinger 1	101	0.25
Impinger 2	15	0.25

Volume of Gas Sampled ($dsft^3$):	49.564
Tunnel Flow Rate ($dsft^3$/min):	470.8448005

Results:

Average Concentration (mg/L):	2.32E-01
Weight (as Nitrogen [g]):	1.16E-04
Weight (as NH_3, [g]):	1.41E-04
Total Concentraion of NH_3 (mg/L):	2.82E-01
Volume of Ammonia Gas Present (L):	9.41E-05
ppmV in Dilution Tunnel:	6.70E-02
Emissions Rate (g/hr):	8.03E-02

NH_3 Emissions Rate (g/hr) :	**0.08**

Appliance:	EPA Wood Stove	**Burn Rate:**	High	**Run #:**	2
Fuel:	Birch	**Date:**	3/9/2011		

Reporting Units: ◉ Total ug ○ mg/L

Run Information:

	Catch (Total ug)	Volume (L)
Impinger 1	293	0.25
Impinger 2	39	0.25

Volume of Gas Sampled (dsft^3):	62.31
Tunnel Flow Rate (dsft^3/min):	459.4510771

Results:

Average Concentration (mg/L):	6.64E-01
Weight (as Nitrogen [g]):	3.32E-04
Weight (as NH3, [g]):	4.03E-04
Total Concentraion of NH3 (mg/L):	8.06E-01
Volume of Ammonia Gas Present (L):	2.69E-04
ppmV in Dilution Tunnel:	1.53E-01
Emissions Rate (g/hr):	1.78E-01

NH3 Emissions Rate (g/hr) :	**0.18**

Appliance:	EPA Wood Stove	Burn Rate:	High	Run #:	3
Fuel:	Spruce	Date:	3/12/11		

Reporting Units: ◉ Total ug ○ mg/L

Run Information:

	Catch (Total ug)	Volume (L)
Impinger 1	152	0.25
Impinger 2	26	0.25

Volume of Gas Sampled ($dsft^3$):	51.64
Tunnel Flow Rate ($dsft^3$/min):	461.2901

Results:

Average Concentration (mg/L):	3.56E-01
Weight (as Nitrogen [g]):	1.78E-04
Weight (as NH3, [g]):	2.16E-04
Total Concentraion of NH3 (mg/L):	4.32E-01
Volume of Ammonia Gas Present (L):	1.44E-04
ppmV in Dilution Tunnel:	9.87E-02
Emissions Rate (g/hr):	1.16E-01

NH3 Emissions Rate (g/hr) :	**0.12**

Appliance:	EPA Wood Stove	Burn Rate:	Low	Run #:	5
Fuel:	Birch	**Date:**	3/17/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	4.31	0.25
Impinger 2	0.191	0.25

Volume of Gas Sampled (dsft^3):	158.1
Tunnel Flow Rate (dsft^3/min):	464.6458794

Results:

Average Concentration (mg/L):	2.25E+00
Weight (as Nitrogen [g]):	1.13E-03
Weight (as NH3, [g]):	1.37E-03
Total Concentration of NH3 (mg/L):	2.73E+00
Volume of Ammonia Gas Present (L):	9.12E-04
ppmV in Dilution Tunnel:	2.04E-01
Emissions Rate (g/hr):	2.41E-01

NH3 Emissions Rate (g/hr) :	**0.24**

Appliance:	EPA Wood Stove	**Burn Rate:**	Low	**Run #:**	6
Fuel:	Spruce	**Date:**	3/18/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	1.75	0.25
Impinger 2	0.123	0.25

Volume of Gas Sampled ($dsft^3$):	118.85
Tunnel Flow Rate ($dsft^3$/min):	477.7274609

Results:

Average Concentration (mg/L):	9.37E-01
Weight (as Nitrogen [g]):	4.68E-04
Weight (as NH3, [g]):	5.69E-04
Total Concentration of NH3 (mg/L):	1.14E+00
Volume of Ammonia Gas Present (L):	3.80E-04
ppmV in Dilution Tunnel:	1.13E-01
Emissions Rate (g/hr):	1.37E-01

NH3 Emissions Rate (g/hr) :	**0.14**

Appliance:	EPA OWHH	**Burn Rate:**	High	**Run #:**	8
Fuel:	Birch	**Date:**	3/22/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	24.5	0.25
Impinger 2	0.666	0.25

Volume of Gas Sampled (dsft^3):	138.65
Tunnel Flow Rate (dsft^3/min):	468.0051

Results:

Average Concentration (mg/L):	1.26E+01
Weight (as Nitrogen [g]):	6.29E-03
Weight (as NH3, [g]):	7.64E-03
Total Concentration of NH3 (mg/L):	1.53E+01
Volume of Ammonia Gas Present (L):	5.10E-03
ppmV in Dilution Tunnel:	1.30E+00
Emissions Rate (g/hr):	1.55E+00

NH3 Emissions Rate (g/hr) :	**1.55**

Appliance:	EPA OWHH	**Burn Rate:**	Low	**Run #:**	9
Fuel:	Birch	**Date:**	3/22/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	10.8	0.25
Impinger 2	0.45	0.25

Volume of Gas Sampled ($dsft^3$):	347.6
Tunnel Flow Rate ($dsft^3$/min):	494.7029817

Results:

Average Concentration (mg/L):	5.63E+00
Weight (as Nitrogen [g]):	2.81E-03
Weight (as NH3, [g]):	3.42E-03
Total Concentration of NH3 (mg/L):	6.83E+00
Volume of Ammonia Gas Present (L):	2.28E-03
ppmV in Dilution Tunnel:	2.32E-01
Emissions Rate (g/hr):	2.92E-01

NH3 Emissions Rate (g/hr) :	**0.29**

Appliance:	EPA OWHH	**Burn Rate:**	High	**Run #:**	10
Fuel:	Spruce	**Date:**	3/23/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	6.13	0.25
Impinger 2	0.335	0.25

Volume of Gas Sampled (dsft^3):	140.61
Tunnel Flow Rate (dsft^3/min):	462.0291086

Results:

Average Concentration (mg/L):	3.23E+00
Weight (as Nitrogen [g]):	1.62E-03
Weight (as NH3, [g]):	1.96E-03
Total Concentration of NH3 (mg/L):	3.93E+00
Volume of Ammonia Gas Present (L):	1.31E-03
ppmV in Dilution Tunnel:	3.29E-01
Emissions Rate (g/hr):	3.87E-01

NH3 Emissions Rate (g/hr) :	**0.39**

Appliance:	EPA OWHH	Burn Rate:	Low	Run #:	11
Fuel:	Spruce	Date:	3/24/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	12	0.25
Impinger 2	0.648	0.25

Volume of Gas Sampled ($dsft^3$):	359.12
Tunnel Flow Rate ($dsft^3$/min):	479.7847321

Results:

Average Concentration (mg/L):	6.32E+00
Weight (as Nitrogen [g]):	3.16E-03
Weight (as NH3, [g]):	3.84E-03
Total Concentration of NH3 (mg/L):	7.68E+00
Volume of Ammonia Gas Present (L):	2.56E-03
ppmV in Dilution Tunnel:	2.52E-01
Emissions Rate (g/hr):	3.08E-01

NH3 Emissions Rate (g/hr) :	**0.31**

Appliance:	Conventional Wood Stove	**Burn Rate:**	High	**Run #:**	12
Fuel:	Spruce	**Date:**	3/30/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	1.05	0.25
Impinger 2	0.106	0.25

Volume of Gas Sampled (dsft^3):	33.76
Tunnel Flow Rate (dsft^3/min):	444.7836106

Results:

Average Concentration (mg/L):	5.78E-01
Weight (as Nitrogen [g]):	2.89E-04
Weight (as NH3, [g]):	3.51E-04
Total Concentration of NH3 (mg/L):	7.02E-01
Volume of Ammonia Gas Present (L):	2.34E-04
ppmV in Dilution Tunnel:	2.45E-01
Emissions Rate (g/hr):	2.77E-01

NH3 Emissions Rate (g/hr) :	**0.28**

Appliance:	Conventional Wood Stove	**Burn Rate:**	High	**Run #:**	13
Fuel:	Birch	**Date:**	3/31/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	6.84	0.25
Impinger 2	0.265	0.25

Volume of Gas Sampled ($dsft^3$):	17.29
Dilution Factor (Qt/Qf):	17.3353
Tunnel Flow Rate ($dsft^3$/min):	433.3931235

Results:

Average Concentration (mg/L):	3.55E+00
Weight (as Nitrogen [g]):	1.78E-03
Weight (as NH3, [g]):	2.16E-03
Total Concentration of NH3 (mg/L):	4.31E+00
Volume of Ammonia Gas Present (L):	1.44E-03
ppmV in Dilution Tunnel:	2.94E+00
ppmV in Stack:	5.10E+01
Emissions Rate (g/hr):	3.24E+00

NH3 Stack Concentration (ppmV):	**51.01**
NH3 Emissions Rate (g/hr) :	**3.24**

Appliance:	Conventional Wood Stove	Burn Rate:	Low	Run #:	14
Fuel:	Spruce	Date:	4/1/11		

Reporting Units:	○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	3.36	0.25
Impinger 2	0.23	0.25

Volume of Gas Sampled (dsft^3):	37.47
Tunnel Flow Rate (dsft^3/min):	459.842048

Results:

Average Concentration (mg/L):	1.80E+00
Weight (as Nitrogen [g]):	8.98E-04
Weight (as NH3, [g]):	1.09E-03
Total Concentration of NH3 (mg/L):	2.18E+00
Volume of Ammonia Gas Present (L):	7.28E-04
ppmV in Dilution Tunnel:	6.86E-01
Emissions Rate (g/hr):	8.02E-01

NH3 Emissions Rate (g/hr) :	**0.80**

Appliance:	Conventional Wood Stove	**Burn Rate:**	Low	**Run #:**	15
Fuel:	Birch	**Date:**	4/1/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	7.8	0.25
Impinger 2	0.414	0.25

Volume of Gas Sampled ($dsft^3$):	36.66
Tunnel Flow Rate ($dsft^3$/min):	446.1506608

Results:

Average Concentration (mg/L):	4.11E+00
Weight (as Nitrogen [g]):	2.05E-03
Weight (as NH3, [g]):	2.49E-03
Total Concentration of NH3 (mg/L):	4.99E+00
Volume of Ammonia Gas Present (L):	1.67E-03
ppmV in Dilution Tunnel:	1.60E+00
Emissions Rate (g/hr):	1.82E+00

NH3 Emissions Rate (g/hr) :	**1.82**

Appliance:	Oil Furnace	**Burn Rate:**	Single	**Run #:**	17
Fuel:	No 2 Heating Oil	**Date:**	4/12/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	0.186	0.25
Impinger 2	0.156	0.25

Volume of Gas Sampled (dsft^3):	388.8511
Tunnel Flow Rate (dsft^3/min):	429.8975

Results:

Average Concentration (mg/L):	1.71E-01
Weight (as Nitrogen [g]):	8.55E-05
Weight (as NH3, [g]):	1.04E-04
Total Concentration of NH3 (mg/L):	2.08E-01
Volume of Ammonia Gas Present (L):	6.93E-05
ppmV in Dilution Tunnel:	6.30E-03
Emissions Rate (g/hr):	6.89E-03

NH3 Emissions Rate (g/hr) :	**0.01**

Appliance:	Waste Oil Burner	**Burn Rate:**	Single	**Run #:**	18
Fuel:	Waste Oil	**Date:**	4/15/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	0.172	0.25
Impinger 2	0.092	0.25

Volume of Gas Sampled ($dsft^3$):	103.44
Tunnel Flow Rate ($dsft^3$/min):	445.7873

Results:

Average Concentration (mg/L):	1.32E-01
Weight (as Nitrogen [g]):	6.60E-05
Weight (as NH3, [g]):	8.01E-05
Total Concentration of NH3 (mg/L):	1.60E-01
Volume of Ammonia Gas Present (L):	5.35E-05
ppmV in Dilution Tunnel:	1.83E-02
Emissions Rate (g/hr):	2.07E-02

NH3 Emissions Rate (g/hr) :	**0.02**

Appliance:	Coal Stove	**Burn Rate:**	High	**Run #:**	20
Fuel:	Dry Stoker Coal	**Date:**	5/6/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	2.4	0.25
Impinger 2	0.245	0.25

Volume of Gas Sampled ($dsft^3$):	100.3418
Tunnel Flow Rate ($dsft^3$/min):	460.1363

Results:

Average Concentration (mg/L):	1.32E+00
Weight (as Nitrogen [g]):	6.61E-04
Weight (as NH3, [g]):	8.03E-04
Total Concentration of NH3 (mg/L):	1.61E+00
Volume of Ammonia Gas Present (L):	5.36E-04
ppmV in Dilution Tunnel:	1.89E-01
Emissions Rate (g/hr):	2.21E-01

NH3 Emissions Rate (g/hr) :	**0.22**

Appliance:	Coal Stove	**Burn Rate:**	Low	**Run #:**	21
Fuel:	Dry Stoker Coal	**Date:**	5/9/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	21.4	0.25
Impinger 2	0.645	0.25

Volume of Gas Sampled (dsft^3):	196.6714
Tunnel Flow Rate (dsft^3/min):	478.2646

Results:

Average Concentration (mg/L):	1.10E+01
Weight (as Nitrogen [g]):	5.51E-03
Weight (as NH3, [g]):	6.69E-03
Total Concentration of NH3 (mg/L):	1.34E+01
Volume of Ammonia Gas Present (L):	4.47E-03
ppmV in Dilution Tunnel:	8.03E-01
Emissions Rate (g/hr):	9.76E-01

NH3 Emissions Rate (g/hr) :	**0.98**

Appliance:	Coal Stove	**Burn Rate:**	Low **Run #:** 23
Fuel:	Wet Stoker Coal	**Date:**	5/11/11

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	18	0.25
Impinger 2	5.57	0.25

Volume of Gas Sampled ($dsft^3$):	162.0401
Tunnel Flow Rate ($dsft^3/min$):	467.5876

Results:

Average Concentration (mg/L):	1.18E+01
Weight (as Nitrogen [g]):	5.89E-03
Weight (as NH3, [g]):	7.16E-03
Total Concentration of NH3 (mg/L):	1.43E+01
Volume of Ammonia Gas Present (L):	4.78E-03
ppmV in Dilution Tunnel:	1.04E+00
Emissions Rate (g/hr):	1.24E+00

NH3 Emissions Rate (g/hr) :	**1.24**

Appliance:	Non Qualified OWHH	**Burn Rate:**	High	**Run #:**	25
Fuel:	Spruce	**Date:**	5/27/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	5.14	0.25
Impinger 2	0.532	0.25

Volume of Gas Sampled (dsft^3):	24.0723
Tunnel Flow Rate (dsft^3/min):	387.2835

Results:

Average Concentration (mg/L):	2.84E+00
Weight (as Nitrogen [g]):	1.42E-03
Weight (as NH3, [g]):	1.72E-03
Total Concentration of NH3 (mg/L):	3.44E+00
Volume of Ammonia Gas Present (L):	1.15E-03
ppmV in Dilution Tunnel:	1.69E+00
Emissions Rate (g/hr):	1.66E+00

NH3 Emissions Rate (g/hr) :	**1.66**

Appliance:	Non Qualified OWHH	Burn Rate:	Low	Run #:	26
Fuel:	Wet Stoker Coal	Date:	5/30/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	36.7	0.25
Impinger 2	0.776	0.25

Volume of Gas Sampled ($dsft^3$):	48.8859
Tunnel Flow Rate ($dsft^3/min$):	424.9401

Results:

Average Concentration (mg/L):	1.87E+01
Weight (as Nitrogen [g]):	9.37E-03
Weight (as NH3, [g]):	1.14E-02
Total Concentration of NH3 (mg/L):	2.28E+01
Volume of Ammonia Gas Present (L):	7.60E-03
ppmV in Dilution Tunnel:	5.49E+00
Emissions Rate (g/hr):	5.93E+00

NH3 Emissions Rate (g/hr) :	**5.93**

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	27
Fuel:	Coal with Retrofit Catalyst	**Date:**	6/1/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	48.8	0.25
Impinger 2	1.54	0.25

Volume of Gas Sampled (dsft^3):	73.3998
Tunnel Flow Rate (dsft^3/min):	426.929

Results:

Average Concentration (mg/L):	2.52E+01
Weight (as Nitrogen [g]):	1.26E-02
Weight (as NH3, [g]):	1.53E-02
Total Concentration of NH3 (mg/L):	3.06E+01
Volume of Ammonia Gas Present (L):	1.02E-02
ppmV in Stack:	#REF!
Emissions Rate (g/hr):	5.33E+00

NH3 Emissions Rate (g/hr) :	**5.33**

Appliance:	Auger Fed HH	**Burn Rate:**	Single, Cold Start	**Run #:**	28
Fuel:	Wet Stoker Coal	**Date:**	6/7/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	1.5	0.25
Impinger 2	0.716	0.25

Volume of Gas Sampled ($dsft^3$):	85.68
Tunnel Flow Rate ($dsft^3$/min):	427.5965

Results:

Average Concentration (mg/L):	1.11E+00
Weight (as Nitrogen [g]):	5.54E-04
Weight (as NH3, [g]):	6.73E-04
Total Concentration of NH3 (mg/L):	1.35E+00
Volume of Ammonia Gas Present (L):	4.49E-04
ppmV in Dilution Tunnel:	1.85E-01
Emissions Rate (g/hr):	2.01E-01

NH3 Emissions Rate (g/hr) :	**0.20**

Appliance:	Auger Fed HH	**Burn Rate:**	Single	**Run #:**	29
Fuel:	Wet Stoker Coal	**Date:**	6/7/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	0.286	0.25
Impinger 2	0.214	0.25

Volume of Gas Sampled (dsft^3):	94.1
Tunnel Flow Rate (dsft^3/min):	410.0643

Results:

Average Concentration (mg/L):	2.50E-01
Weight (as Nitrogen [g]):	1.25E-04
Weight (as NH3, [g]):	1.52E-04
Total Concentration of NH3 (mg/L):	3.04E-01
Volume of Ammonia Gas Present (L):	1.01E-04
ppmV in Dilution Tunnel:	3.80E-02
Emissions Rate (g/hr):	3.97E-02

NH3 Emissions Rate (g/hr) :	**0.04**

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	30
Fuel:	Spruce	**Date:**	6/30/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	8.28	0.25
Impinger 2	0.708	0.25

Volume of Gas Sampled ($dsft^3$):	66.7505
Tunnel Flow Rate ($dsft^3$/min):	412.9678

Results:

Average Concentration (mg/L):	4.49E+00
Weight (as Nitrogen [g]):	2.25E-03
Weight (as NH3, [g]):	2.73E-03
Total Concentration of NH3 (mg/L):	5.46E+00
Volume of Ammonia Gas Present (L):	1.82E-03
ppmV in Dilution Tunnel:	9.64E-01
Emissions Rate (g/hr):	1.01E+00

NH3 Emissions Rate (g/hr) :	**1.01**

Appliance:	Non Qualified OWHH	**Burn Rate:**	High **Run #:** 31
Fuel:	Birch	**Date:**	7/1/11

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	26.7	0.25
Impinger 2	2.31	0.25

Volume of Gas Sampled (dsft^3):	45.4303
Tunnel Flow Rate (dsft^3/min):	367.8844

Results:

Average Concentration (mg/L):	1.45E+01
Weight (as Nitrogen [g]):	7.25E-03
Weight (as NH3, [g]):	8.81E-03
Total Concentration of NH3 (mg/L):	1.76E+01
Volume of Ammonia Gas Present (L):	5.88E-03
ppmV in Dilution Tunnel:	4.57E+00
Emissions Rate (g/hr):	4.28E+00

NH3 Emissions Rate (g/hr) :	**4.28**

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low **Run #:** 32
Fuel:	Birch	**Date:**	7/6/11

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	18	0.25
Impinger 2	0.978	0.25

Volume of Gas Sampled (dsft^3):	75.9649
Tunnel Flow Rate (dsft^3/min):	413.0445

Results:

Average Concentration (mg/L):	9.49E+00
Weight (as Nitrogen [g]):	4.74E-03
Weight (as NH3, [g]):	5.76E-03
Total Concentration of NH3 (mg/L):	1.15E+01
Volume of Ammonia Gas Present (L):	3.85E-03
ppmV in Dilution Tunnel:	1.79E+00
Emissions Rate (g/hr):	1.88E+00

NH3 Emissions Rate (g/hr) :	**1.88**

Appliance:	Non Qualified OWHH	**Burn Rate:**	Low	**Run #:**	33
Fuel:	Birch, Cold Start	**Date:**	7/8/2011		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	49.6	0.25
Impinger 2	2.55	0.25

Volume of Gas Sampled ($dsft^3$):	109.5025
Tunnel Flow Rate ($dsft^3$/min):	407.1146

Results:

Average Concentration (mg/L):	2.61E+01
Weight (as Nitrogen [g]):	1.30E-02
Weight (as NH3, [g]):	1.58E-02
Total Concentration of NH3 (mg/L):	3.17E+01
Volume of Ammonia Gas Present (L):	1.06E-02
ppmV in Dilution Tunnel:	3.41E+00
Emissions Rate (g/hr):	3.53E+00

NH3 Emissions Rate (g/hr) :	**3.53**

Appliance:	EPA OWHH	**Burn Rate:**	Low	**Run #:**	34
Fuel:	Birch w/ Retrofit Catalyst	**Date:**	7/27/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	4.91	0.25
Impinger 2	0.389	0.25

Volume of Gas Sampled ($dsft^3$):	153.4584
Tunnel Flow Rate ($dsft^3/min$):	502.8851

Results:

Average Concentration (mg/L):	2.65E+00
Weight (as Nitrogen [g]):	1.32E-03
Weight (as NH3, [g]):	1.61E-03
Total Concentration of NH3 (mg/L):	3.22E+00
Volume of Ammonia Gas Present (L):	1.07E-03
ppmV in Dilution Tunnel:	2.47E-01
Emissions Rate (g/hr):	3.16E-01

NH3 Emissions Rate (g/hr) :	**0.32**

Appliance:	Coal Stove	**Burn Rate:**	High	**Run #:**	35
Fuel:	Wet Stoker Coal	**Date:**	8/10/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	1.22	0.25
Impinger 2	0.119	0.25

Volume of Gas Sampled ($dsft^3$):	44.1109
Tunnel Flow Rate ($dsft^3$/min):	569.458

Results:

Average Concentration (mg/L):	6.70E-01
Weight (as Nitrogen [g]):	3.35E-04
Weight (as NH3, [g]):	4.06E-04
Total Concentration of NH3 (mg/L):	8.13E-01
Volume of Ammonia Gas Present (L):	2.71E-04
ppmV in Dilution Tunnel:	2.17E-01
Emissions Rate (g/hr):	3.15E-01

NH3 Emissions Rate (g/hr) :	**0.31**

Appliance:	Coal Stove	**Burn Rate:**	Low, Cold Start	**Run #:**	36
Fuel:	Wet Lump Coal	**Date:**	8/11/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	42.8	0.25
Impinger 2	14.6	0.25

Volume of Gas Sampled ($dsft^3$):	245.9403
Tunnel Flow Rate ($dsft^3$/min):	488.8577

Results:

Average Concentration (mg/L):	2.87E+01
Weight (as Nitrogen [g]):	1.44E-02
Weight (as NH3, [g]):	1.74E-02
Total Concentration of NH3 (mg/L):	3.49E+01
Volume of Ammonia Gas Present (L):	1.16E-02
ppmV in Dilution Tunnel:	1.67E+00
Emissions Rate (g/hr):	2.08E+00

NH3 Emissions Rate (g/hr) :	**2.08**

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	37
Fuel:	Wet Lump Coal	Date:	8/12/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	18.7	0.25
Impinger 2	1.05	0.25

Volume of Gas Sampled ($dsft^3$):	183.5963
Tunnel Flow Rate ($dsft^3$/min):	488.5701

Results:

Average Concentration (mg/L):	9.88E+00
Weight (as Nitrogen [g]):	4.94E-03
Weight (as NH3, [g]):	6.00E-03
Total Concentration of NH3 (mg/L):	1.20E+01
Volume of Ammonia Gas Present (L):	4.00E-03
ppmV in Dilution Tunnel:	7.70E-01
Emissions Rate (g/hr):	9.57E-01

NH3 Emissions Rate (g/hr) :	**0.96**

Appliance:	Coal Stove	Burn Rate:	Low	Run #:	38
Fuel:	Dry Lump Coal	Date:	8/15/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	11.6	0.25
Impinger 2	0.274	0.25

Volume of Gas Sampled ($dsft^3$):	181.931
Tunnel Flow Rate ($dsft^3$/min):	515.7899

Results:

Average Concentration (mg/L):	5.94E+00
Weight (as Nitrogen [g]):	2.97E-03
Weight (as NH3, [g]):	3.60E-03
Total Concentration of NH3 (mg/L):	7.21E+00
Volume of Ammonia Gas Present (L):	2.41E-03
ppmV in Dilution Tunnel:	4.67E-01
Emissions Rate (g/hr):	6.13E-01

NH3 Emissions Rate (g/hr) :	**0.61**

Appliance:	Coal Stove	**Burn Rate:**	Low, Coal Start	**Run #:**	39
Fuel:	Wet Stoker Coal	**Date:**	8/16/11		

Reporting Units: ○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	32.8	0.25
Impinger 2	1.65	0.25

Volume of Gas Sampled ($dsft^3$):	206.8815
Tunnel Flow Rate ($dsft^3$/min):	522.0733

Results:

Average Concentration (mg/L):	1.72E+01
Weight (as Nitrogen [g]):	8.61E-03
Weight (as NH3, [g]):	1.05E-02
Total Concentration of NH3 (mg/L):	2.09E+01
Volume of Ammonia Gas Present (L):	6.98E-03
ppmV in Dilution Tunnel:	1.19E+00
Emissions Rate (g/hr):	1.58E+00

NH3 Emissions Rate (g/hr) :	**1.58**

Appliance:	Oil Furnace	Burn Rate:	Single	Run #:	40
Fuel:	No. 1 Fuel Oil	Date:	8/17/11		

Reporting Units:	○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	0.729	0.25
Impinger 2	0.424	0.25

Volume of Gas Sampled ($dsft^3$):	545.9553
Tunnel Flow Rate ($dsft^3$/min):	518.3042

Results:

Average Concentration (mg/L):	5.77E-01
Weight (as Nitrogen [g]):	2.88E-04
Weight (as NH3, [g]):	3.50E-04
Total Concentration of NH3 (mg/L):	7.00E-01
Volume of Ammonia Gas Present (L):	2.34E-04
ppmV in Dilution Tunnel:	1.51E-02
Emissions Rate (g/hr):	1.99E-02

NH3 Emissions Rate (g/hr) :	**0.02**

Appliance:	EPA Wood Stove	Burn Rate:	Low, Cold Start	Run #:	41
Fuel:	Birch	Date:	8/18/11		

Reporting Units:	○ Total ug ◉ mg/L

Run Information:

	Catch (mg/l)	Volume (L)
Impinger 1	3.46	0.25
Impinger 2	0	0.25

Volume of Gas Sampled ($dsft^3$):	144.7273
Tunnel Flow Rate ($dsft^3$/min):	477.4781

Results:

Average Concentration (mg/L):	1.73E+00
Weight (as Nitrogen [g]):	8.65E-04
Weight (as NH3, [g]):	1.05E-03
Total Concentration of NH3 (mg/L):	2.10E+00
Volume of Ammonia Gas Present (L):	7.01E-04
ppmV in Dilution Tunnel:	1.71E-01
Emissions Rate (g/hr):	2.08E-01

NH3 Emissions Rate (g/hr) :	**0.21**

Measurement of Space-Heating Emissions

Appendix E

Lab Notes

Run Notes

Client: Fairbanks North Star Borough
Model: Pellet Stove ⇒ High
Project #: 477-S-1-1
Tracking #: ______
Run #: 1 Date: 3/8/11
Test Crew: S. Button, L. Pitzman
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: on High

SECONDARY: N/A
TERTIARY: N/A
FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
—	N/A	—	—	—	—	

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Pellets

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: N/A
DOOR: N/A
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: on High

SECONDARY: N/A
TERTIARY: N/A
FAN: N/A

Technician signature: [signature] Date: 3/8/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1
Date: 3/8/11
Appliance: Pellet stove *Fuel:* Pellets *Burn Rate:* High

Filter Data

T1: *ID:* A7518410 *167404* *D/T In Freezer:* 3/8/11 16:20 *Preliminary Weight:* —
Q1: *ID:* A7518410 *D/T In Freezer:* 3/8/11 16:20 *Preliminary Weight:* —
Q2: *ID:* FNB #1 *D/T In Freezer:* 3/8/11 16:20 *Preliminary Weight:* .1437
Q3: *ID:* FNB #2 *D/T In Freezer:* 3/8/11 16:20 *Preliminary Weight:* .1402
Q4: *ID:* FNB # 3 *D/T In **Dessicator:*** 3/8/11 16:20 *Preliminary Weight:* .1452

Q1 Weight record:

D/T:	3/14/11 10:30	3/15/11 10:40	
Audit:	.501	.501	
Temp:	72°	74	
Humidity:	5.4%	3.6%	
Weight:	.1452	.1451	

Supplementary Data

Pre-test

Gas Analyzer Train: ϕ
Ammonia Train: 0.006 @ -8"
Box A: 0.010 @ -10"
Box B: 0.014 @ -5"

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

PRE	Zero	Span	Mid
O_2	-0.01	20.94	10.64
CO_2	0.00	16.75	10.08
CO	0.00	4.33	2.51

Post-Test

Gas Analyzer Train: ϕ
Box A: .010 @ -10"
Box B: .012 @ -5"

POST	Zero	Span	Mid
O_2	0.04	20.98	10.65
CO_2	0.03	16.78	10.12
CO	-0.00	4.30	2.50

Flow Rate Check:
T1: 4887 mL/min
Q1: 102.6 mL/min
Q2: 4029 mL/min
Q3: 1551 mL/min
Q4: — mL/min

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

[signature] 3/15/11

Run Notes

Client: Fairbanks North Star Borough
Model: EPA Stove - ~~Spruce~~ JB Birch - High
Project #: 477-S-1-1
Tracking #: ______
Run #: 2 Date: 3/9/11
Test Crew: A. Kravitz, S. Button, J. Clark
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: fully open

SECONDARY: fixed

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
55:00	Added 3 lbs					
70:00	Added 5 lbs					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Front :

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 2:00
DOOR: Closed @ 2:00
PRIMARY AIR: fully open

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: fully open

SECONDARY: fixed

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 3/10/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/9/11

Appliance: EPA Stove *Fuel:* ~~Spruce~~ Birch JB *Burn Rate:* High

Filter Data

T1: *ID:* A751810N - * 16791* *D/T In Freezer:* 3/9/11 16:30

Q1: *ID:* A751856I *D/T In Freezer:* 3/9/11 16:30

Q2: *ID:* FNB #4 *D/T In Freezer:* 3/9/11 16:30 *Preliminary Weight:*

Q3: *ID:* FNB #5 *D/T In Freezer:* 3/9/11 16:30 *Preliminary Weight:*

Q4: *ID:* FNB #6 *D/T In Dessicator:* 3/9/11 16:30 *Preliminary Weight:*

Q4 weight record:			
	D/T: 3/14/11 10:30	D/T: 3/15/11 10:40	D/T:
	Audit: .5001	Audit: .5001	Audit:
	Temp: 72'	Temp: 74'	Temp:
	Humidity: 5.4%	Humidity: 3.6%	Humidity:
	Weight: .1433	Weight: .1432	Weight:

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: 0.008 @ -12.5"

Box A: 0.004 @ -7"

Box B: 0.013 @ -9"

Post-Test

Leaks: Gas Analyzer Train: ∅

Box A: 0.009 @ -7"

Box B: 0.006 @ -9"

PRE	Zero	Span	Mid
O_2	See other Sheet		
CO_2	↓	↓	↓
CO			

POST	Zero	Span	Mid
O_2	See other Sheet		
CO_2	↓	↓	↓
CO			

Flow Rate Check:

T1: 5697 mL/min Q2: 3991 mL/min

Q1: 1039 mL/min Q3: 1580 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 2-1 *D/T in Fridge:* 3/9/11 16:30

Impinger 2: *Bottle Number:* 2-2 *D/T in Fridge:* 3/9/11 16:30

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/15/11

FUEL DATA

Client: Fairbanks North Star Borough
Model: EPA stove - SB Birch - High
Project #: 477-S-1-1 Tracking #: ____
Date: 3/9/11 Test Crew: S. Button Run #: 2
OMNI Equipment ID #: ____
FUEL LOAD PREPARED BY: A. Krasite
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER:~~ SB Birch, Cordwood

PRE-BURN FUEL

Kindling: 5.5 lbs

MOISTURE CONTENT (METER – – DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12%
Cal Value (2) = 22% Actual Reading 22%

Piece	Length	Readings			Type
1	ft	18.3	19	18.8	cordwood
2	ft	20.3	20.4	18	↓
3	ft	18	21.1	18.9	

16.0 lbs

Length of cut pieces: ≈16 inches Pre-Burn Fuel Average Moisture: 19.2%

Time (clock): ____ Room Temperature (F): 65 Initials: SB

TEST FUEL

FUEL TYPE AND AMOUNT: SB cordwood 5 4 × 4 ____
CALCULATED LOAD WEIGHT: ____ ACTUAL LOAD WEIGHT: ____ (2 × 4)
(4 × 4)
FUEL PIECE LENGTH: ≈ 16 inches 16.4 lbs Total

MOISTURE CONTENT (METER – – DRY BASIS)

PIECE	READINGS			TYPE
1	18.2	18.2	18.0	cordwood
2	14.0	15.7	13.7	↓
3	16.7	16.6	19	
4	17.5	16.7	14.9	
5	21.8	25.2	21.3	
6				
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: 17.83%

Time (clock): ____ Room Temperature (F): 65 Initials: SB

Technician signature: [signature] Date: 3/9/11

OMNI-Test Laboratories, Inc.

Run Notes

Client: Fairbanks North Star Borough
Model: EPA stove - spruce - High
Project #: 477-S-1-1
Tracking #:
Run #: 3 Date: 3/10/11
Test Crew: J. Button, A. Kravitz, J. Clark
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Fully open

SECONDARY: Fixed

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
40 min	Added 4.5 lbs of wood					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done @ 20 sec
DOOR: Closed @ 45 sec
PRIMARY AIR: Set @ 0 sec
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Fully open

SECONDARY: Fixed

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 3/10/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/10/11

Appliance: Epa Stove *Fuel:* Spruce *Burn Rate:* High

Filter Data

T1: *ID:* A7518090 *16792* *D/T In Freezer:* 3/10 2:30 *Preliminary Weight:* N/A

Q1: *ID:* A7518550 *D/T In Freezer:* 3/10 2:30 *Preliminary Weight:*

Q2: *ID:* FNB #7 *D/T In Freezer:* 3/10 2:30 *Preliminary Weight:*

Q3: *ID:* FNB#8 *D/T In Freezer:* 3/10 2:30 *Preliminary Weight:*

Q4: *ID:* FNB#9 *D/T In* **Dessicator:** 3/10 2:30 *Preliminary Weight:* .1451

Q1 Weight record:			
D/T:	3/14/11 10:30	3/15/11 10:40	
Audit:	.5001	.5001	
Temp:	72'	74'	
Humidity:	5.4%	3.6%	
Weight:	.1447	.1448	

Supplementary Data

Pre-test

Gas Analyzer Train: ∅ Box A: 0.004 @ -13"

Ammonia Train: 0.005@-11 Box B: 0.013 @ -10"

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

PRE	Zero	Span	Mid
O_2	See	other data	sheet
CO_2	↓	↓	↓
CO			

Post-Test

Gas Analyzer Train: ∅

Box A: .004 @ -13"

Box B: .013 @ -10"

POST	Zero	Span	Mid
O_2	-0.10	21.10	10.66
CO_2	0.06	16.86	10.18
CO	-0.00	4.34	2.52

Flow Rate Check:

T1: 5445 mL/min Q3: 1563 mL/min

Q1: 1043 mL/min Q4: N/A mL/min

Q2: 3869 mL/min

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/15/11

FUEL DATA

Client: Fairbanks North Star Borough
Model: EPA Stove - Spruce - High Burn
Project #: 477-S-1-1 Tracking #: _____
Date: 3/10/11 Test Crew: S. Button Run #: 3
OMNI Equipment ID #: _____
FUEL LOAD PREPARED BY: A. Kravitz
FUEL: ~~DOUGLAS-FIR SPECIES,~~ UNTREATED, AIR-DRIED, STANDARD ~~GRADE OR BETTER~~, ~~DIMENSIONAL LUMBER.~~ SB Spruce, cordwood

PRE-BURN FUEL

Kindling: 4.7 lbs

MOISTURE CONTENT (METER – – DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12%
Cal Value (2) = 22% Actual Reading 22%

Piece	Length	Readings			Type
1	___ ft	21.9	20.9	15.4	cordwood
2	___ ft	16.6	15.2	30.7	↓
3	___ ft	15.7	16.3	17.6	

Length of cut pieces: ≈ 16" inches
Pre-Burn Fuel Average Moisture:

Time (clock): _____ Room Temperature (F): 65° Initials: SB

16.0 lbs

TEST FUEL

FUEL TYPE AND AMOUNT: ~~2×4~~ SB cordwood - 4 4 × 4 _____
CALCULATED LOAD WEIGHT: _____ ACTUAL LOAD WEIGHT: _____ (2 × 4)
_____ (4 × 4)
16.1 Total
FUEL PIECE LENGTH: ≈ 16"

MOISTURE CONTENT (METER – – DRY BASIS)

PIECE	READINGS			TYPE
1	28.3	24.7	28.2	Cordwood
2	18.2	15.5	18.5	↓
3	32.3	30.0	31.0	
4	17.8	17.6	18.0	
5				
6				
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: 23.75%

Time (clock): _____ Room Temperature (F): 65 Initials: SB

Technician signature: [signature] Date: 3/10/11

Run Notes

Client: Fairbanks North Star Borough
Model: EPA Birch Low 2
Project #: 477-S-1-1
Tracking #:
Run #: 5 Date: 3/17/11
Test Crew: A. Kravitz, S. Button, D. Clark
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1/4" from fully closed

SECONDARY: ~~N/A~~ Fixed

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
None ←						

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

cordwood (6 pcs.)

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done @ 30 sec
DOOR: Closed @ 5 min
PRIMARY AIR: set @ 7 min

OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

1/4" from fully closed

SECONDARY: fixed

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 3/18/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/17/11

Appliance: EPA Stove *Fuel:* Birch *Burn Rate:* Low #2

Filter Data

change @ 28:00

T1: *ID:* A751977 + A751801M *D/T In Freezer:* 3/17 4:00

Q1: *ID:* A751853Y *D/T In Freezer:* 3/17 4:00

Q2: *ID:* FNB #14 *D/T In Freezer:* 3/17 4:06 *Preliminary Weight:* .1508

Q3: *ID:* FNB #15 *D/T In Freezer:* 3/17 4:00 *Preliminary Weight:* .1482

Q4: *ID:* FNB #16 / FNB #17 changed 28:00 *D/T In Dessicator:* 3/17 4:06 *Preliminary Weight:* .1440

Q4 weight record:			
D/T:	3/25/11 2:00	3/28/11	3/29/11
Audit:	.5002	.5001	.5002
Temp:	73.0	73	73
Humidity:	5.1	2.2	6.1
Weight:	.1689 / .1434	.1688 / .1432	.1690 / .1432

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: .007 @ -13"

Box A: .002 @ -18"

Box B: .003 @ -19"

Post-Test

Leaks: Gas Analyzer Train: ∅

Box A: .007 @ -13"

Box B: .009 @ -8"

PRE	Zero	Span	Mid
O_2	SEE OES GAS DATA		
CO_2			
CO			

POST	Zero	Span	Mid
O_2	See OES Gas Data		
CO_2	↓	↓	↓
CO			

Flow Rate Check:

T1: 2555 mL/min Q2: 3150 mL/min

Q1: 1073 mL/min Q3: 1590 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 5-1 *D/T in Fridge:* 3/17 4:15

Impinger 2: *Bottle Number:* 5-2 *D/T in Fridge:* 3/17 4:15

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/29/11

Kindling: 5.0 lb
Preburn: 15.9 lb
Test load: 15.9 lb

FUEL DATA

Client: FNB
Model: EPA Birch Low 2
Project #: 477-S-01-1 Tracking #: ____
Date: 3/17/11 Test Crew: AH, SB, JC Run #: 5
OMNI Equipment ID #: ____
FUEL LOAD PREPARED BY: AH
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ Birch cordwood

PRE-BURN FUEL

MOISTURE CONTENT (METER – – DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12.0%
Cal Value (2) = 22% Actual Reading 22.0%

Piece	Length	Readings			Type
1	____ ft	163	159	165	157
2	____ ft	143	145	148	194
3	____ ft	182	176	177	168

172

Length of cut pieces: ~16" inches

Pre-Burn Fuel Average Moisture:

Time (clock): ____ Room Temperature (F): 68 Initials: AH

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A

CALCULATED LOAD WEIGHT: 15.9 ACTUAL LOAD WEIGHT: ____ (2 × 4)
____ (4 × 4)
15.9 Total

FUEL PIECE LENGTH: ~16"

MOISTURE CONTENT (METER – – DRY BASIS)

PIECE	READINGS			TYPE
1	174	186	161	Cord
2	153	154	156	
3	163	165	157	
4	170	184	178	
5	181	180	171	
6	156	160	155	
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: 16.7%

Time (clock): 8:30 Room Temperature (F): 68 Initials: AH

Technician signature: [signature] Date: 3/17/11

Run Notes

Client: FNB
Model: EPA Stove Spruce Low
Project #: 477-S-01-1
Tracking #:
Run #: 6 Date: 3/18/11
Test Crew: A. Kravitz, J. Clark, S. Button
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1/4" from fully closed

SECONDARY: fixed

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

cordwood (4 pcs)

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done @ 1 min
DOOR: closed @ 4 min
PRIMARY AIR: Set @ 5 min
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

1/4" from fully closed

SECONDARY: fixed

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 3/18/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/18/11

Appliance: EPA Stove *Fuel:* Spruce *Burn Rate:* Low

Filter Data

T1: *ID:* A7518075 *16794* *D/T In Freezer:* 3/18/11 16:20

Q1: *ID:* A751842 V *D/T In Freezer:* 3/18/11 16:20

Q2: *ID:* FNB #18 *D/T In Freezer:* 3/18/11 16:20 *Preliminary Weight:* .1417

Q3: *ID:* FNB #19 *D/T In Freezer:* 3/18/11 16:20 *Preliminary Weight:* .1395

Q4: *ID:* FNB #20 *D/T In Dessicator:* 3/18/11 16:24 *Preliminary Weight:* .1454

Q4 weight record:			
D/T:	3/25/11	3/28/11	3/29/11
Audit:	.5002	.5001	.5002
Temp:	73.0	73	73
Humidity:	5.1	2.2	6.1
Weight:	~~.2098~~ .1447	.1451	.1449

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: .011 @ -12"

Box A: .010 @ -10"

Box B: .003 @ -7"

Post-Test

Leaks: Gas Analyzer Train: ∅

Box A: .001 @ -8.8

Box B: .003 @ -7.0

PRE	Zero	Span	Mid
O_2	See gas Data		
CO_2	↓	↓	↓
CO	↓	↓	↓

POST	Zero	Span	Mid
O_2	↓	↓	↓
CO_2	↓	↓	↓
CO	↓	↓	↓

Flow Rate Check:

T1: 815 mL/min Q2: 1565 mL/min

Q1: 960 mL/min Q3: 1490 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 6-1 *D/T in Fridge:* 3/18/11 16:30

Impinger 2: *Bottle Number:* 6.2 *D/T in Fridge:* 3/18/11 16:30

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/29/11

Kindling: 5 lb
Preburn: 16.1 lb
Test: 16.0 lb

FUEL DATA

Client: FNB
Model: EPA Stove Spruce Low
Project #: 477-S-01-1 Tracking #: ____
Date: 3/18/11 Test Crew: AK, SB, JC Run #: 6
OMNI Equipment ID #: 340
FUEL LOAD PREPARED BY: A. Kravitz
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ Spruce Cordwood

PRE-BURN FUEL

MOISTURE CONTENT (METER – – DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12.0
Cal Value (2) = 22% Actual Reading 22.0

Piece	Length	Readings			Type
1	____ ft	21.9	14.4	16.6	23.0
2	____ ft	17.2	14.8	15.5	20.4
3	____ ft	15.4	21.7	14.1	14.4

Length of cut pieces: ~16 inches Pre-Burn Fuel Average Moisture:

Time (clock): ____ Room Temperature (F): ____ Initials: AK

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A
CALCULATED LOAD WEIGHT: 16.0 ACTUAL LOAD WEIGHT: ____ (2 × 4)
____ (4 × 4)
16.0 Total
FUEL PIECE LENGTH: ~16"

MOISTURE CONTENT (METER – – DRY BASIS)

PIECE	READINGS			TYPE
1	14.1	14.2	14.9	cord
2	14.5	17.2	14.1	|
3	22.3	22.5	21.0	|
4	20.6	23.1	16.2	|
5				
6				
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: 17.9%

Time (clock): 11:15 Room Temperature (F): 70 Initials: AK

Technician signature: [signature] Date: 3/18/11

Run Notes

Client: Fairbank North Star Borough
Model: Phase II Boiler Birch Hi 2
Project #: 477-S-1-1
Tracking #: 8
Run #: 8 Date: 3/22/11
Test Crew: S Buffer, J Clark
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: on high

SECONDARY: Fixed
TERTIARY: Fixed
FAN: Fixed

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
30 min	add 40 lbs of preburn fuel					
76 min	stirred coals					
125 min	stirred coals					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

cord wood

START UP PROCEDURES
BYPASS: NA
FUEL LOADING: Done @ 90 sec
DOOR: closed 2 min
PRIMARY AIR: N/A
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: High

SECONDARY: Fixed
TERTIARY: Fixed
FAN: Fixed

Technician signature: [signature] Date: 3/22/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/22/11

Appliance: Phase II Build *Fuel:* Birch *Burn Rate:* High

Filter Data

T1: *ID:* A751804P *16797* *D/T In Freezer:* 3/22/11 15:00

Q1: *ID:* A751852X *D/T In Freezer:* 3/22/11 15:00

Q2: *ID:* FNB#27 *D/T In Freezer:* 3/22/11 15:00 *Preliminary Weight:* .1455

Q3: *ID:* FNB#26 *D/T In Freezer:* 3/22/11 15:00 *Preliminary Weight:* .1685

Q4: *ID:* FNB#25 *D/T In* **Dessicator:** 3/22/11 15:00 *Preliminary Weight:* .1827

Q4 weight record:			
D/T:	3/25/11	3/28/11	3/29/11
Audit:	.5004	.5001	.5002
Temp:	73	73	73
Humidity:	5.1	2.2	6.1
Weight:	.1817	.1816	.1816

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: Ø

Ammonia Train: .002@-10"

Box A: .005 @ -18"

Box B: .002 @ -10"

Post-Test

Leaks: Gas Analyzer Train: Ø

Box A: .006 @ -15"

Box B: .005 @ -17"

PRE	Zero	Span	Mid
O_2	See	OES Data	Sheet
CO_2	↓	↓	↓
CO			

POST	Zero	Span	Mid
O_2			
CO_2			
CO	↓	↓	↓

Flow Rate Check:

T1: ~~415.4~~ 923.86 mL/min Q2: 1443.5 mL/min

Q1: 1068.9 mL/min Q3: 1332.3 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 8-1 *D/T in Fridge:* 3/22/11 15:00

Impinger 2: *Battle Number:* 8-1 *D/T in Fridge:* 3/22/11 15:00

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/29/11

Run 8

Boiler Fuel Moisture

Client: FNB
Model: EPA Boiler Birch High 2
Project Number: 477-S-01-1

Preburn Weight: 100.1 lb
Fuel Weight: 140.2 lb

Readings:

16.3	17.5	17.9	19.1	17.8
18.5	15.5	15.7	23.2	18.4
15.9	19.1	16.3	17.4	
17.6	18.1	16.0	13.1	
26.7	17.9	22.2	19.8	
18.7	17.3	17.5	17.6	
14.7	18.1	16.3	19.9	
18.4	14.1	18.0	19.7	
24.9	18.6	16.4	20.5	
16.9	23.8	18.1	13.9	
16.0	16.7	16.5	20.6	

Average: **18.11** % Dry Basis

4/26/11

Run Notes

Client: Fairbanks North Star Borough
Model: Phase II Boiler Birch Low
Project #: 477-S-1-1
Tracking #:
Run #: 9 Date: 3/22/11
Test Crew: A. [illegible], S. Button
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: On Low

SECONDARY: Fixed
TERTIARY: Fixed
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
1:15:00	Coals Stirred					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 2 min
DOOR: Closed @ 2 min
PRIMARY AIR: N/A
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Low

SECONDARY: Fixed
TERTIARY: Fixed
FAN:

Technician signature: [signature] Date: 3/23/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/22/11

Appliance: Phase II OWHH *Fuel:* Brch *Burn Rate:* Low

Filter Data

T1: *ID:* A7518030 *16798* *D/T In Freezer:* 3/23 4:00

Q1: *ID:* A751851W *D/T In Freezer:* 3/23 4:00

Q2: *ID:* FNB #28 *D/T In Freezer:* 3/23 4:00 *Preliminary Weight:* .1565

Q3: *ID:* FNB #29 *D/T In Freezer:* 3/23 4:00 *Preliminary Weight:* .1561

Q4: *ID:* FNB #30 FNB #31 *D/T In Dessicator:* 3/23 4:00 *Preliminary Weight:* .1620

Q4 weight record:					
D/T:	3/25/11	3/28/11	3/29/11	4/5/11	4/11
Audit:	.5002	.5001	.5002	.5002	.5002
Temp:	73	73	73	73	75.4
Humidity:	5.1	2.2	6.1	5.1	8.1
Weight:	.2107 / .1613	.2107 / .1616	.2105 / .1610	.2091 / .1611	.2092 / [illegible]

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: .010 @ -11"

Box A: .003 @ -10"

Box B: .004 @ -15"

Post-Test

Leaks: Gas Analyzer Train: ~~∅~~ Failed post test leak check

Box A: .005 @ -10

Box B: .005 @ -15"

PRE	Zero	Span	Mid
O_2	See other Data		
CO_2	↓	↓	↓
CO	↓	↓	↓

POST	Zero	Span	Mid
O_2	↓	↓	↓
CO_2	↓	↓	↓
CO	↓		

Flow Rate Check:

T1: 780.85 mL/min Q2: 1755.1 mL/min

Q1: 875.09 mL/min Q3: 1351.4 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 9-1 *D/T in Fridge:* 4:00 3/23

Impinger 2: *Bottle Number:* 9-2 *D/T in Fridge:* 4:00 3/2~

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/23

Run 9

Boiler Fuel Moisture

Client: FNB
Model: EPA Boiler Birch Low
Project Number: 477-S-01-1

Preburn Weight: 100.0 lb
Fuel Weight: 140.2 lb

Readings:

22.8	14.0	14.5	19.1	15.6
15.5	16.8	15.8	16.6	18.7
11.6	14.1	18.1	14.7	18.4
18.5	16.7	16.7	15.5	
16.0	18.2	19.8	18.1	
14.0	17.8	17.9	14.5	
16.7	13.3	18.0	18.0	
13.1	17.0	17.9	13.6	
14.3	16.1	20.6	21.6	
13.9	13.5	15.4	15.0	
15.9	17.3	16.5	13.1	

Average: **16.40** % Dry Basis

3/22/16

Run Notes

Client: Fairbanks North Star Borough
Model: EPA OWHH Spruce high
Project #: 477-S-1-1
Tracking #: _____
Run #: 10 Date: 3/23/11
Test Crew: J. Button, J. Clark
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: on High

SECONDARY: Fixed
TERTIARY: Fixed
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cord wood

START UP PROCEDURES
BYPASS: Closed @ 90 sec
FUEL LOADING: Closed @ 1 min ≤ switch!
DOOR: Done @ 45 sec
PRIMARY AIR: N/A
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: on high

SECONDARY: Fixed
TERTIARY: Fixed
FAN:

Technician signature: [signature] Date: 3/23/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/23/11

Appliance: EPA OWHH *Fuel:* Spruce *Burn Rate:* High

Filter Data

T1: *ID:* A7517988 X 17004 *D/T In Freezer:* 3/23/11 16:30

Q1: *ID:* A751850 V *D/T In Freezer:* 3/23/11 16:30

Q2: *ID:* FNB #34 *D/T In Freezer:* 3/23/11 16:30 *Preliminary Weight:*

Q3: *ID:* FNB #33 *D/T In Freezer:* 3/23/11 16:30 *Preliminary Weight:*

Q4: *ID:* FNB #32 + FNB #35 *D/T In Dessicator:* 3/23/11 16:30 *Preliminary Weight:* .1537 / .1512

Q4 weight record:	D/T: 3/25/11	D/T: 3/28	D/T: 3/29	4/5
	Audit: .5002	Audit: .5001	Audit: .5002	.5002
	Temp: 73	Temp: 73	Temp: 73	73
	Humidity: 5.1	Humidity: 2.2	Humidity: 6.1	5.1
	Weight: .1550 .1517	Weight: .1537 .1513	Weight: .1533 .1510	.1534 .1511

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: .004 @ -10"

Box A: .009 @ -11.5"

Box B: .001 @ -10"

Post-Test

Leaks: Gas Analyzer Train: ∅

Box A: .005 @ -10"

Box B: .003 @ -9"

PRE	Zero	Span	Mid
O_2	See	other data	sheet
CO_2	↓	↓	↓
CO			

POST	Zero	Span	Mid
O_2	↓	↓	↓
CO_2			
CO			

Flow Rate Check:

T1: 798 mL/min Q2: 1571 mL/min

Q1: 1051 mL/min Q3: 1640 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 10-1 *D/T in Fridge:* 16:45 3/23/11

Impinger 2: *Bottle Number:* 10-2 *D/T in Fridge:* 16:45 3/23/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 4/5/11

Run 10

Boiler Fuel Moisture

Client: FNB
Model: EPA Boiler Spruce High
Project Number: 477-S-01-1

Preburn Weight: 100 lb
Fuel Weight: 140 lb

Readings:

19.4	22.0	13.7	32.3
26.4	18.3	13.4	25.1
26.8	21.3	29.3	21.4
31.2	21.3	24.2	13.9
16.3	20.0	14.8	17.1
33.0	13.2	12.7	26.4
25.3	26.9	15.7	18.2
13.1	14.2	14.9	20.1
13.2	14.9	13.2	21.7
16.5	35.2	12.3	33.7
23.4	27.0	20.5	

Average: **20.78** % Dry Basis

4/26/11

Run Notes

Client: Fairbanks North Star Borough
Model: EPA OWHH Spruce Low
Project #: 477-S-1-1
Tracking #: ____
Run #: 11 Date: 3/24/11
Test Crew: S. Button
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Cat II

SECONDARY: Fixed
TERTIARY: Fixed
FAN: Fixed

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
N/A						

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood

START UP PROCEDURES
BYPASS: Closed @ 1 min
FUEL LOADING: Done @ 45 sec
DOOR: Closed @ 1 min
PRIMARY AIR: N/A
OTHER: ____

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Cat II

SECONDARY: Fixed
TERTIARY: Fixed
FAN: Fixed

Technician signature: [signature] Date: 3/24/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1
Date: 3/24/11
Appliance: EPA OWHH *Fuel:* Spruce *Burn Rate:* Low

Filter Data

T1: *ID:* A75100L *17002* *D/T In Freezer:* 3/24 9:15
Q1: *ID:* A751844X *D/T In Freezer:* 3/24 9:15
Q2: *ID:* FNB#36 *D/T In Freezer:* 3/24 9:15 *Preliminary Weight:* .1795
Q3: *ID:* FNB#37 *D/T In Freezer:* 3/24 9:15 *Preliminary Weight:* .1560
Q4: *ID:* FNB# 38 #39 *D/T In Dessicator:* 3/24 9:30 *Preliminary Weight:* .2361 .1569

Q4 weight record:	D/T: 3/25	D/T: 3/28	D/T: 3/29	4/5	4/11
	Audit: .5002	Audit: .5001	Audit: .5002	.5002	.5002
	Temp: 73	Temp: 73	Temp: 73	73	75.4
	Humidity: 5.1	Humidity: 2.2	Humidity: 6.1	5.1	8.1
	Weight: .2349 .1573	Weight: .2338 .1567	Weight: .2320 .1562	.2290 .1560	.2288

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: Ø
Ammonia Train: .004@ 12"
Box A: .002 @ -10"
Box B: .007 @ -11"

Post-Test

Leaks: Gas Analyzer Train: Ø
Box A: .006 @ -10"
Box B: .019 @ -12"

PRE	Zero	Span	Mid
O_2	See other data sheet		
CO_2	↓	↓	↓
CO			

POST	Zero	Span	Mid
O_2	↓	↓	↓
CO_2			
CO			

Flow Rate Check:

T1: .9145 L/min Q2: 4.7830 L/min
Q1: 1.1167 L/min Q3: 1.6122 L/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 11-1 *D/T in Fridge:* 3/24 9:00
Impinger 2: *Bottle Number:* 11-2 *D/T in Fridge:* 3/24 9:00

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/27

Run 11

Boiler Fuel Moisture

Client: FNB
Model: EPA Boiler Spruce Low
Project Number: 477-S-01-1

Preburn Weight: 100 lb
Fuel Weight: 141 lb

Readings:

29.1	28.6	15.4	19.8
29.0	15.8	26.0	17.4
24.6	17.9	23.6	21.8
21.1	20.4	20.4	22.3
27.0	15.4	16.1	28.1
15.3	13.8	15.3	19.8
16.6	14.5	15.3	17.4
24.2	14.8	14.9	21.3
20.2	25.4	18.8	18.7
15.0	21.8	21.4	
17.5	22.4	29.3	

Average: **20.32** % Dry Basis

3/24/14

Run Notes

Client: FNB
Model: Conventional Stove Spruce High
Project #: 477-S-01-1
Tracking #: ____
Run #: 12 Date: 3/30/11
Test Crew: AH, SB, JC
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

Maxed out

SECONDARY: N/A

TERTIARY:

FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
36:00	Added 6.4 lb					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Maxed Out

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 30 sec
DOOR: Closed @ 30 sec
PRIMARY AIR: Fully open

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Cordwood

SECONDARY: N/A

TERTIARY:

FAN:

Technician signature: [signature] Date: 3/30/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1
Date: 3/30/11
Appliance: Conventional Stove *Fuel:* Spruce *Burn Rate:* high

Filter Data

T1: *ID:* A751826V *D/T In Freezer:* 3/30/11
Q1: *ID:* A751840T *D/T In Freezer:* 3/30/11
Q2: *ID:* FNB #40 *D/T In Freezer:* 3/30/11 *Preliminary Weight:* N/A
Q3: *ID:* FNB #41 *D/T In Freezer:* 3/30/11 *Preliminary Weight:* N/A
Q4: *ID:* FNB #s 42+43 *D/T In Dessicator:* 3/30/11 *Preliminary Weight:* 42: .1402 43: .1432

Q4 weight record:			
D/T:	4/5/11	4/11/11	4/12
Audit:	.5002	.5002	.5002
Temp:	73	75.4	77.4
Humidity:	5.1	8.1	9.5
Weight:	.1348/.1432	~~.1412~~ .1399 / ~~.1432~~	N/A / .1431

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: 0.002@-10" (AY)
Ammonia Train: ∅
Box A: 0.000@-11"
Box B: 0000@-11"

Post-Test

Leaks: Gas Analyzer Train: ∅
Box A: .000 @ -11"
Box B: .000 @ -11"

PRE	Zero	Span	Mid
O_2	See	OES	Data
CO_2	↓	↓	↓
CO	↓	↓	↓

POST	Zero	Span	Mid
O_2	↓	↓	↓
CO_2	↓	↓	↓
CO	↓	↓	↓

Flow Rate Check:
T1: 857.52 mL/min Q2: 3701.7 mL/min
Q1: 901.43 mL/min Q3: 1531.3 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:
Impinger 1: *Bottle Number:* 12-1 *D/T in Fridge:* 3/30/11
Impinger 2: *Bottle Number:* 12-2 *D/T in Fridge:* 3/30/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 3/30/11

Kindling
Pre : 15 lb
Test : 14.7 lb

FUEL DATA

Client: FNB
Model: Conventional Stove Spruce High
Project #: 477-S-01-1 Tracking #: ____
Date: 3/30/16 Test Crew: ____ Run #: 12
OMNI Equipment ID #: ____
FUEL LOAD PREPARED BY: A. Kravitz
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ spruce cordwood

PRE-BURN FUEL

MOISTURE CONTENT (METER -- DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading ____
Cal Value (2) = 22% Actual Reading ____

Piece	Length	Readings			
1	___ ft	14.9	13.7	13.0	13.8
2	___ ft	14.1	12.2	14.7	15.4
3	___ ft	13.2	15.2		

Length of cut pieces: ~16 inches Pre-Burn Fuel Average Moisture:

Time (clock): ____ Room Temperature (F): 71 Initials: AK

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A
CALCULATED LOAD WEIGHT: 14.7 ACTUAL LOAD WEIGHT: ____ (2 × 4)
____ (4 × 4)
14.7 Total
FUEL PIECE LENGTH: ~16"

MOISTURE CONTENT (METER -- DRY BASIS)

PIECE	READINGS			TYPE
1	18.4	19.6	19.8	cord
2	13.9	13.4	13.8	|
3	19.1	19.0	20.1	|
4	16.3	17.9	17.8	|
5				
6				
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: 17.38

Time (clock): ____ Room Temperature (F): 71 Initials: AK

Technician signature: [signature] Date: 3/30/16

15:00 Replace Q4 (FNB #47)
19:00 Replace G1 + T1 (A75(K)5...

Run Notes

Client: FNB
Model: Conventional Stove Birch High
Project #: 477-S-01-1
Tracking #: ____
Run #: 13
Date: 3/31/11
Test Crew: Aaron K, J Clark
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: On High

SECONDARY: N/A
TERTIARY: N/A
FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
24:00	Added 8 lb					
45:00	Added 5.7 lb					
1:05:00	Added 6.7 lb					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

cordwood

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 1:00
DOOR: Closed @ 1:30
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: On high

SECONDARY: N/A
TERTIARY: N/A
FAN: N/A

Technician signature: Aaron Kravitz Date: 3/3/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1
Date: 3/31/11
Appliance: Conventional Stove *Fuel:* Birch *Burn Rate:* High

Filter Data

T1: *ID:* A751814R + A751825U *D/T In Freezer:* 3/31/11 13:00
Q1: *ID:* A7518390 *D/T In Freezer:* 3/31/11 13:00
Q2: *ID:* FNB #44 *D/T In Freezer:* 3/31/11 13:00 *Preliminary Weight:* N/A
Q3: *ID:* FNB #45 *D/T In Freezer:* 3/31/11 13:00 *Preliminary Weight:* N/A
Q4: *ID:* FNB # 46/47 *D/T In Dessicator:* 3/31/11 13:00 *Preliminary Weight:* .1617 / .1530

Q4 weight record:			
D/T:	4/5/11	4/11/11	4/12
Audit:	.5002	.5002	.5002
Temp:	73	75.4	77.4
Humidity:	5.1	8.1	9.5
Weight:	.1585/.1526	.1576/.1522	.1576/.1520

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ~~.006@-15"~~ for ∅
Ammonia Train: .006@-15"
Box A: .003 @ -10"
Box B: .011 @ -10"

Post-Test

Leaks: Gas Analyzer Train: ~~∅~~ 5B
Box A: ∅ @
Box B: ∅ @
failed post-test leak check

Flow Rate Check:
T1: 644.48 mL/min Q2: 5187.0 mL/min
Q1: 8027.6 mL/min Q3: 1231.0 mL/min

PRE	Zero	Span	Mid
O_2	N/A	N/A	N/A
CO_2			
CO			

POST	Zero	Span	Mid
O_2			
CO_2			
CO			

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 13-1 *D/T in Fridge:* 3/31/11 12:40
Impinger 2: *Bottle Number:* 13-2 *D/T in Fridge:* 3/31/11 12:40

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 4/12/11

FUEL DATA

Client: FNB
Model: Conventional Stove Birch High
Project #: 477-S-01-1 Tracking #: ____
Date: 3/3/11 Test Crew: AU, SB, JC Run #: 13
OMNI Equipment ID #: ____
FUEL LOAD PREPARED BY: AU
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ Birch cordwood

PRE-BURN FUEL

MOISTURE CONTENT (METER — — DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading ____
Cal Value (2) = 22% Actual Reading ____

Piece	Length	Readings			Type
1	____ ft	15.0	24.3	13.4	14.4
2	____ ft	12.9	12.4	18.4	16.5
3	____ ft	14.5	17.2	17.7	14.7

Length of cut pieces: ~16 inches Pre-Burn Fuel Average Moisture:

Time (clock): ____ Room Temperature (F): 71 Initials: AU

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 ____ 4 × 4 ____
CALCULATED LOAD WEIGHT: ____ ACTUAL LOAD WEIGHT: NA (2 × 4)
NA (4 × 4)
~~14.00~~ 14.9 Total

FUEL PIECE LENGTH: ____

MOISTURE CONTENT (METER — — DRY BASIS)

PIECE	READINGS			TYPE
1	14.6	12.5	15.3	Cold
2	16.3	16.8	12.4	↓
3	23.9	32.7	20.3	↓
4	16.5	16.5	13.2	↓
5	15.4	16.7	17.1	↓
6	13.2	15.3	13.1	
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: ____

Time (clock): ____ Room Temperature (F): 71 Initials: AU

Technician signature: [signature] Date: 3/31/11

Run Notes

Client: FNB
Model: Conventional Stove Spruce Low
Project #: 477-S-01-1
Tracking #: ______
Run #: 14 Date: ~~3/30/11~~ 4/1/11
Test Crew: AH, SA, JC
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: On Low

SECONDARY: N/A
TERTIARY:
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
33:00	Added 6.1 15					
52:00	Added 7.1 14					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood (4 pcs)

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Door @ ~~2min~~ 30 sec
DOOR: Closed @ 1 min
PRIMARY AIR: N/A
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: On low

SECONDARY: N/A
TERTIARY:
FAN:

Technician signature: [signature] Date: 4/1/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 3/31/11

Appliance: Conventional Stove *Fuel:* Spruce *Burn Rate:* Low

Filter Data

T1: *ID:* A751855 *16786K *D/T In Freezer:* 4/1/11

Q1: *ID:* A751832T *D/T In Freezer:* 4/1/11

Q2: *ID:* FNB#48 *D/T In Freezer:* 4/1/11 *Preliminary Weight:* N/A

Q3: *ID:* FNB #49 *D/T In Freezer:* 4/1/11 *Preliminary Weight:* N/A

Q4: *ID:* FNB # 50 / FNB #51 *D/T In Dessicator:* 4/1/11 *Preliminary Weight:* .1499 / .1451

Q4 weight record:			
D/T:	4/5/11	4/11/11	4/12
Audit:	.5002	.5002	.5002
Temp:	73	75.4	77.4
Humidity:	5.1	8.1	9.5
Weight:	.1491/.1451	.1488/.1450	.1487/N/A

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ∅

Ammonia Train: .005@-15"

Box A: .006 @ -11

Box B: .011 @ -9

Post-Test

Leaks: Gas Analyzer Train: ∅

Box A: .006 @ -7"

Box B: .015 @ -11"

PRE	Zero	Span	Mid
O_2	SEE	OES	DATA
CO_2			
CO			

POST	Zero	Span	Mid
O_2			
CO_2			
CO			

Flow Rate Check:

T1: 756 mL/min Q2: 3603 mL/min

Q1: 937 mL/min Q3: 1535 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 14-1 *D/T in Fridge:* 4/1/11 12:30

Impinger 2: *Bottle Number:* 14-2 *D/T in Fridge:* 4/1/11 12:30

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 4/12/11

Preburn: 15 lb
Test: 14.8 lb

FUEL DATA

Client: FNB
Model: Conventional Stove Spruce Low
Project #: 477-S-01-1 Tracking #: ____
Date: 4/1/11 Test Crew: AH, SB, JC Run #: 14
OMNI Equipment ID #: ____
FUEL LOAD PREPARED BY: AH
FUEL: ~~DOUGLAS-FIR~~ SPECIES, ~~UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ spruce cordwood

PRE-BURN FUEL

MOISTURE CONTENT (METER – – DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12.0
Cal Value (2) = 22% Actual Reading 22.0

Piece	Length	Readings			~~Type~~
1	____ ft	27.6	14.0	24.1	32.1
2	____ ft	21.9	23.6	36.3	26.1
3	____ ft	21.3	24.1		

Length of cut pieces: ~16 inches Pre-Burn Fuel Average Moisture:

Time (clock): ____ Room Temperature (F): 69 Initials: AH

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A
CALCULATED LOAD WEIGHT: 14.8 ACTUAL LOAD WEIGHT: ____ (2 × 4)
____ (4 × 4)
14.8 Total
FUEL PIECE LENGTH: ~16"

MOISTURE CONTENT (METER – – DRY BASIS)

PIECE	READINGS			TYPE
1	19.0	21.5	20.2	
2	19.3	21.9	19.4	
3	15.0	14.9	14.9	
4	15.1	15.3	15.9	
5				
6				
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: ____

Time (clock): ____ Room Temperature (F): 69 Initials: AH

Technician signature: [signature] Date: 4/1/11

Run Notes

Client: FNB
Model: Conventional Stove Birch Low
Project #: 477-S-01-1
Tracking #: 48
Run #: 15 Date: 4/11 4/1/11
Test Crew:
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: On low

SECONDARY: N/A
TERTIARY:
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
37:00	Added 4/3 11.6					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood (6 pcs)

START UP PROCEDURES
~~BYPASS~~: Done @ 45 sec
FUEL LOADING DOOR: Closed @ 1 min
PRIMARY AIR: set continuously
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: On low

SECONDARY: N/A
TERTIARY:
FAN:

Technician signature: [signature] Date: 4/1/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 4/1/11

Appliance: Conventional Stove *Fuel:* Birch *Burn Rate:* Low

Filter Data

T1: *ID:* A751816T *D/T In Freezer:* 4/1/11

T1 (2): *ID:* N/A Changed @: *D/T In Freezer:*

Q1: *ID:* A751836X *D/T In Freezer:* 4/1/11

Q2: *ID:* FNB #52 *D/T In Freezer:* 4/1/11

Q3: *ID:* FNB #53 *D/T In Freezer:* 4/1/11

Q4: *ID:* FNB #54 *D/T In Dessicator:* 4/1/11 Prelim: .1632

Q4 (2): *ID:* FNB #55 Changed @: 21:00 *D/T In Dessicator:* 4/1/11 Prelim: .1436

Q4 weight record:			
D/T:	4/5/11	4/11	4/12
Audit:	.5001	.5002	.5002
Temp:	73	75.4	77.4
Humidity:	51	8.1	9.5
Weight:	.1613/.1432	.1601/.1429	.1599/.1428

Supplementary Data

Pre-test

Leaks: Gas Analyzer Train: ϕ Ammonia Train: .004 @ -15"

Box A: .008 @ -11" Box B: .016 @ -11"

Post-Test

Leaks: Gas Analyzer Train: ϕ

Box A: .008 @ -11" Box B: .019 @ -11"

Flow Rate Check:

T1: 783 mL/min Q2: 3769 mL/min

Q1: 997 mL/min Q3: 1561 mL/min

Calibration Values:

Zero:	0.00% O_2	0.00% CO_2	0.000% CO
Span:	20.95% O_2	16.76% CO_2	4.327% CO
Mid:	10.56% O_2	10.17% CO_2	2.512% CO

Ammonia Sample:

Impinger 1: *Bottle Number:* 15-1 *D/T in Fridge:* 4/1/11

Impinger 2: *Bottle Number:* 15-2 *D/T in Fridge:* 4/1/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Gas Bottles: AWC858 (Zero), CC337886 (Span), CC75242 (Mid)

Technician Signature/Date: [signature] 4/12/11

FUEL DATA

Client: FNB
Model: Conventional Stove Birch Low
Project #: 477-S-01-1 Tracking #: _____
Date: 4/1/11 Test Crew: AH, SB, JC Run #: 15
OMNI Equipment ID #: ______
FUEL LOAD PREPARED BY: AH
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED,~~ STANDARD ~~GRADE OR BETTER~~, ~~DIMENSIONAL LUMBER.~~ Birch cordwood

PRE-BURN FUEL
MOISTURE CONTENT (METER -- DRY BASIS)

CALIBRATION: Cal Value (1) = 12% Actual Reading 12.6
Cal Value (2) = 22% Actual Reading 22.0

Piece	Length	Readings			~~Type~~	
1	___ ft	14.0	22.2	25.4	14.5	
2	___ ft	23.8	15.7	15.2	28.8	
3	___ ft	17.7	26.3	14.5	16.5	16.3

Length of cut pieces: ~16 inches Pre-Burn Fuel Average Moisture:

Time (clock): ______ Room Temperature (F): 70 Initials: AH

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A
CALCULATED LOAD WEIGHT: ______ ACTUAL LOAD WEIGHT: ______ (2 × 4)
______ (4 × 4)
FUEL PIECE LENGTH: ~16" 14.0 Total

MOISTURE CONTENT (METER -- DRY BASIS)

PIECE	READINGS			TYPE
1	AH ~~11.9~~	~~11.0~~	~~10.5~~	Cord
2	~~11.9~~			↓
3	11.9	11.0	10.5	
4	11.9	11.8	11.9	
5	13.3	13.8	15.5	
6	15.3	16.6	15.2	
7	15.9	14.9	16.1	
8	14.4	17.4	14.7	↓
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: ______

Time (clock): ______ Room Temperature (F): 70 Initials: AH

Technician signature: [signature] Date: 4/1/11

Run Notes

Client: FNB
Model: No 2 Fuel Oil
Project #: 477-S-01-1
Tracking #: ____
Run #: 17 Date: 4/12/11
Test Crew: AH, SD
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Fixed

SECONDARY: Auto
TERTIARY:
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None →					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

No. 2 Oil

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING DOOR:
PRIMARY AIR:
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Fixed

SECONDARY: Auto
TERTIARY:
FAN:

Technician signature: [signature] Date: 4/12/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: **4/12/11** *Run #:* **17** *Appliance/Fuel/Burn Rate:* **No 2 Fuel Oil**

Filter Data

T1: *ID:* A751818V

T1 (2): *ID:* N/A

Time Changed:

Q1: *ID:* A7518334

Q2: *ID:* FNB #59

Q3: *ID:* FNB # 60

Q4: *ID:* FNB #61 *Preliminary Weight:* .1457

Q4 (2): *ID:* N/A *Preliminary Weight:*

Time Changed:

Date/time Samples placed in freezer/dessicator: 4/12/11 9:22PM

Q4 weight record:			
D/T:	4/17/11 14:00	4/18/11 8:30	
Audit:	.5002	.5002	
Temp:	74.0	76.7	
Humidity:	5.8	8.4	
Weight (1):	.1458	.1458	
Weight (2):	N/A	N/A	

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅

Ammonia Train: .003@ -15

Box A: .006 @ -7"

Box B: .001 @ -10"

Post-Test Leaks:

Gas Analyzer Train: ∅

Box A: .008 @ -7"

Box B: .001 @ -10"

Flow Rate Check:

T1: 872.12 mL/min Q2: 3019.1 mL/min

Q1: 1086.6 mL/min Q3: 1567.3 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 17-1 *D/T in Fridge:* 4/12 9:40

Impinger 2: *Bottle Number:* 17-2 *D/T in Fridge:* 4/12 9:40

Technician Signature/Date: [signature] 4/18/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run Notes

Client: FNSB
Model: Waste Oil Burner
Project #: 477-S-01-1
Tracking #: ____
Run #: 18 Date: 4/15/11
Test Crew: AK, SB
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: ON

SECONDARY: N/A
TERTIARY:
FAN:

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
—	N/A	—	—	—	—	—

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

waste oil

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING
DOOR:
PRIMARY AIR:
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: ON

SECONDARY: N/A
TERTIARY:
FAN:

Technician signature: [signature] Date: 4/15/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 4/15/11 *Run #:* 18 *Appliance/Fuel/Burn Rate:* Waste Oil Burner

Filter Data

T1: *ID:* A751824T

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A751829Y

Q2: *ID:* FNB#62

Q3: *ID:* FNB#63

Q4: *ID:* FNB#64 *Preliminary Weight:* .1579

Q4 (2): *ID:* FNB#65 *Preliminary Weight:* .1511

Time Changed: 1:08:00

Date/time Samples placed in freezer/dessicator: 4/15/11 12:00

Q4 weight record:			
D/T:	4/17/11 14:00	4/18/11 8:30	
Audit:	.5002	.5002	
Temp:	74.0	76.7	
Humidity:	5.8	8.4	
Weight (1):	.1556	.1557	
Weight (2):	.1493	.1495	

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: 0

Ammonia Train: .006 @ -12"

Box A: .003 @ -8"

Box B: .001 @ -11"

Post-Test Leaks:

Gas Analyzer Train: 0

Box A: .004 @ -12"

Box B: .003 @ -10"

Flow Rate Check:

T1: 3754 mL/min Q2: 4271 mL/min

Q1: 3699 mL/min Q3: 1728 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 18-1 *D/T in Fridge:* 4/15/11 12:00

Impinger 2: *Bottle Number:* 18-2 *D/T in Fridge:* 4/15/11 12:00

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 4/18/11

Run Notes

8.7 lb bird kindling
30 lb preburn
22.4 lb test fuel

Client: Fairbanks North Star Borough
Model: Coal Stove - Dry Stoker coal - High Burn
Project #: 477-S-1-1
Tracking #: ____
Run #: 20 Date: 5/6/11
Test Crew: J. Button
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

Full open
(1 turn per manufacturing instructions)

SECONDARY: N/A
TERTIARY: N/A
FAN: ON

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Stoker Coal

START UP PROCEDURES
BYPASS: Ash Rake, closed @ 3 min
FUEL LOADING: Done @ 2 min
DOOR: closed @ 2 min
PRIMARY AIR: Set @ 0 sec
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A
TERTIARY: N/A
FAN: ON

Technician signature: [signature] Date: 5/6/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 5/6/11 *Run #:* 20 *Appliance/Fuel/Burn Rate:* Coal Stove, Dry Stoker Coal, High Burn

Filter Data

T1: *ID:* A751822R

T1 (2): *ID:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
5/6/11 15:20

Q1: *ID:* A751828Y

Q2: *ID:* FNB # 69

Q3: *ID:* FNB# 70

Q4: *ID:* FNB #71 *Preliminary Weight:* .1690

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Q4 weight record:			
D/T:	5/17 15:00	5/26/11 14:00	
Audit:	.5000	.5001	
Temp:	72.1	73	
Humidity:	16.7	13.14	
Weight (1):	.1683	.1681	
Weight (2):	N/A	N/A	

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅

Ammonia Train: .004 @ -20"

Box A: .008 @ -11"

Box B: .000 @ -8"

Post-Test Leaks:

Gas Analyzer Train: ∅

Box A: .004 @ -10"

Box B: .002 @ -8"

Flow Rate Check:

T1: 223 mL/min Q2: 3548 mL/min

Q1: 849 mL/min Q3: 1392 mL/min

Ammonia Sample:

Impinger 1: *Battle Number:* 20-1 *D/T in Fridge:* 5/6/11 15:00

Impinger 2: *Bottle Number:* 20-2 *D/T in Fridge:* 5/6/11 15:00

Technician Signature/Date: [signature] 5/6/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run Notes

Client: Fairbanks North Star Borough
Model: Coal stove - Dry Stoker Coal - Low Burn
Project #: 477-S-1-1
Tracking #:
Run #: 21 Date: 5/9/11
Test Crew: S. Button
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1/4 open from fully closed

SECONDARY: N/A

TERTIARY: N/A

FAN: ON

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Stoker Coal

START UP PROCEDURES
BYPASS: Ash door, closed @ 5min
FUEL LOADING: Done @ 2min
DOOR: Closed @ 2min
PRIMARY AIR: Set @ 5min

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A

TERTIARY: N/A

FAN: ON

Technician signature: [signature] Date: 5/9/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 5/9/11 *Run #:* 21 *Appliance/Fuel/Burn Rate:* Coal Stove / Dry Stoker Coal / Low Burn

Filter Data

T1: *ID:* A751821Q

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A751837Y

Q2: *ID:* FNB #72

Q3: *ID:* FNB# 73

Q4: *ID:* FNB #74 *Preliminary Weight:* .1705

Q4 (2): *ID:* FNB#75 *Preliminary Weight:* .1487

Time Changed: 61 minutes into test

Date/time Samples placed in freezer/dessicator: 5/9 19:22

Q4 weight record:			
D/T:	5/17 15:00	5/26/11 14:10	
Audit:	.5000	.501	
Temp:	72.1	73	
Humidity:	16.9	13.1%	
Weight (1):	.1651	.1649	
Weight (2):	.1447	.1448	

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅

Ammonia Train: .010 @ -20"

Box A: .005 @ 10"

Box B: .002 @ 15"

Flow Rate Check:

T1: 780.81 mL/min Q2: 3517.1 mL/min

Q1: 893.53 mL/min Q3: 1446.7 mL/min

Post-Test Leaks:

Gas Analyzer Train: ∅

Box A: .007 @ 10"

Box B: .007 @ 12"

Ammonia Sample:

Impinger 1: *Bottle Number:* 21-1 *D/T in Fridge:* 5/9 19:35

Impinger 2: *Bottle Number:* 21-2 *D/T in Fridge:* 5/9 19:35

Technician Signature/Date: [signature] 5/9/2011

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

OMNI-Test Laboratories, Inc.

Fuel
1.7 lb birch kindling
30 lb preburn
221 lb test fuel

Run Notes

Client: Fairbanks North Star Borough
Model: Coal Stove - wet stoker coal - Low Burn
Project #: 477-S-1-1
Tracking #: ______
Run #: 23 Date: 5/11/11
Test Crew: J. Button, J. Clark
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1/4 open from fully closed

SECONDARY: N/A

TERTIARY: N/A

FAN: ON

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

wet stoker coal

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 2:00
DOOR: Closed @ 2:00
PRIMARY AIR: Set @ 5:00

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A

TERTIARY: N/A

FAN: ON

Technician signature: [signature] Date: 5/11/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 5/11/11 *Run #:* 23 *Appliance/Fuel/Burn Rate:* Coal Stove - Wet Stoker -

Filter Data

T1: *ID:* A751820P

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A7518492

Q2: *ID:* FNB 79

Q3: *ID:* FNB 80

Q4: *ID:* FNB 81 *Preliminary Weight:* .1853

Q4 (2): *ID:* FNB 82 *Preliminary Weight:* .1428

Time Changed: 1hr 40min into test

Date/time Samples placed in freezer/dessicator:
5/11/11 17:00

Q4 weight record:			
D/T:	5/17 15:00	5/26/11 14:00	5/27/11 9:00
Audit:	.5000	.5001	.5001
Temp:	72.1	73	73
Humidity:	16.7	13.1%	12.4%
Weight (1):	.1834	.1826	.1828
Weight (2):	.1421	.1420	N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅

Ammonia Train: .003 @ 15"

Box A: .003 @ 15"

Box B: .008 @ 10"

Flow Rate Check:

T1: 142.90 mL/min Q2: 1850.27 mL/min

Q1: 846.63 mL/min Q3: 917.65 mL/min

Post-Test Leaks:

Gas Analyzer Train: ∅

Box A: .003 @ 15"

Box B: .010 @ 11"

Ammonia Sample:

Impinger 1: *Bottle Number:* 23-1 *D/T in Fridge:* 5/11 17:15

Impinger 2: *Bottle Number:* 23-2 *D/T in Fridge:* 5/11 17:15

Technician Signature/Date: [signature] 5/26/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run Notes

Client: Fairbank NorthStar Borough
Model: Non-cat owHH Spruce High
Project #: 477-S-1-1
Tracking #: ____
Run #: 25 Date: 5/27/11
Test Crew: SB Allen
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: ON High

SECONDARY: N/A

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cord wood

START UP PROCEDURES
BYPASS: Closed @ 5 min
FUEL LOADING: Done @ 2 min
DOOR: Closed @ 2 min
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: on high

SECONDARY: N/A

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 5/27/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 5/27/11 *Run #:* 25 *Appliance/Fuel/Burn Rate:* NON-Q OWHH Spruce High

Filter Data

T1: *ID:* A7583519

T1 (2): *ID:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 5/27/11 13:00

Q1: *ID:* A7518476

Q2: *ID:* FNB #87

Q3: *ID:* FNB #D8

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Stack Gas Dilution

Total Flow: 1982.9 mL/min.

Dilution Air Flow: 1386.1 mL/min

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .005 @ -12"

Box A: .010 @ -15"

Box B: N/A

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .012 @ -15"

Box B: N/A

Flow Rate Check:

T1: 168.8 mL/min Q2: 774.1 mL/min

Q1: 924.45 mL/min Q3: 951.3 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 25-1 *D/T in Fridge:* 5/27/11 13:00

Impinger 2: *Bottle Number:* 25-2 *D/T in Fridge:* 5/27/11 13:00

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 5/27/11

Run 25
OWHHNQ - Spruce High
Fuel Moisture

OMNI 183 + 431 - 12.0%, 22.0%

15.4	15.4	Weight: 121.1 lb
16.8	16.1	Preburn: 122.7 lb
18.4	12.5	
13.8	19.3	
16.9	17.5	
A ~~18.8~~ 19.4	16.1	
13.6	20.1	
16.8	15.9	
14.5	18.1	
13.3	21.2	
14.3	14.9	
22.0	15.1	
16.8	14.8	
19.3	24.9	
18.8	15.3	
14.8	18.8	
12.1	21.5	
16.0	18.9	
16.8		
16.1	Avg = 16.91 %	

*Min 30-31 gas train filter changed

Run Notes

Client: Fairbanks research Project
Model: NQ OWHH - Coal
Project #: 477-S-1-1
Tracking #: ____
Run #: 26 Date: 5/30/11
Test Crew: SYBAtm
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

Low heat
burn

SECONDARY: NA

TERTIARY: NA

FAN: AA

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	N/A					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Stoker Coal

START UP PROCEDURES
BYPASS: Closed @ 5min
FUEL LOADING: Done @ 1min
DOOR: Closed @ 3min
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 5/30/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 5/30/11 *Run #:* 26 *Appliance/Fuel/Burn Rate:* Non-Q OWHH - Coal

Filter Data

T1: *ID:* A7583508

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A7518387

Q2: *ID:* FNB# 89

Q3: *ID:* FNB ~~#90~~ #90B

Q4: *ID:* ~~FNB# 905B~~ *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 5/30/11 14:00

Stack Gas Dilution
Total Flow: 1347.0 mL/min
Dilution Air Flow: 121.19 mL/min

Q4 weight record:			
D/T:	N/A		
Audit:			
Temp:			
Humidity:			
Weight (1):			
Weight (2):			

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .006 @ -12"

Box A: .013 @ -15"

Box B: N@A

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .015 @ -16"

Box B: N/@A

Flow Rate Check:

T1: 130.9 mL/min Q2: 1820.3 mL/min

Q1: 1037.6 mL/min Q3: 1002.0 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 26-1 *D/T in Fridge:* 5/30/11 14:15

Impinger 2: *Bottle Number:* 26-2 *D/T in Fridge:* 5/30/11 14:15

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 5/30/11

Run Notes

Client: FNB
Model: NQ0WHH Coal w/ Retrofit Catalyst
Project #: 477-8-01-1
Tracking #: ______
Run #: 27 Date: 6/1/11
Test Crew: ______
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

Low heat draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Aut

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Stoker coal

START UP PROCEDURES
BYPASS: ______
FUEL LOADING: Done @ 4:00
DOOR: ______
PRIMARY AIR: ______
OTHER: ______

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Low heat draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Aut

Technician signature: [signature] Date: 6/1/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 6/1/11 *Run #:* 27 *Appliance/Fuel/Burn Rate:* NQ OWHH Retrofit Catalyst

Filter Data

T1: *ID:* A758338C

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A7518467

Q2: *ID:* FNB 91

Q3: *ID:* FNB 92

Q4: *ID:* ~~FNB 93~~ N/A An *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 6/1 15:30

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1):
	Weight (2):	Weight (2):	Weight (2):

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .004 @ -15"

Box A: .010 @ -11"

Box B: ~~.000 @ -12"~~ N/A An

Post-Test Leaks:

Gas Analyzer Train: Ø - MELTED PROBE

Box A: .013 @ -11"

Box B: N/A @ N/A

Flow Rate Check:

T1: 178.82 mL/min Q2: 1835.1 mL/min

Q1: 1017.0 mL/min Q3: 757.28 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 27-1 *D/T in Fridge:* 6/1 15:30

Impinger 2: *Bottle Number:* 27-2 *D/T in Fridge:* 6/1 15:30

Technician Signature/Date: [signature] 6/1/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

OMNI-Test Laboratories, Inc.

Cold Start

2.0 lb kindling crib (doug fir)
Fuel weight = 150.0 lb
Approx. 10 mL lighter fluid used

Run Notes

Client: Fairbanks North Star Borough
Model: _____
Project #: 477-S-1-1
Tracking #: _____
Run #: 28 Date: 6/7/11
Test Crew: AH, SB, JC
OMNI Equipment ID #(s): _____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

~~~40% full burn~~ AH
Cold start

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
—	None (cold start) —	—	—	—	—	

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Auto-fed stoker
coal (wet)

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: N/A
DOOR: Closed @ 12:00
PRIMARY AIR: Auto

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

~40% full burn

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 6/7/11
~~~

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 6/7/11 *Run #:* 28 *Appliance/Fuel/Burn Rate:* Auger fed Coal Boiler - Cold Start

Filter Data

T1: *ID:* A758349F

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A751835W

Q2: *ID:* FNB #95

Q3: *ID:* FNB #94

Q4: *ID:* FNB #93 *Preliminary Weight:* .1547

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 6/7/11 13:20			

Q4 weight record:			
D/T:	6/15/11	6/28/11	6/29/11
Audit:	.5011	.5002	.5001
Temp:	73.6	74.1	74.6
Humidity:	8.6	10.9	10.0
Weight (1):	.1544	.1530	.1529
Weight (2):	N/A	N/A	N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .012 @ -16"

Box A: .011 @ -15"

Box B: .010 @ -12"

Post-Test Leaks:

Gas Analyzer Train: See run 29

Box A: .009 @ -15"

Box B: ___ @ ___

Flow Rate Check:

T1: 183.52 mL/min Q2: 1726.8 mL/min

Q1: 979.11 mL/min Q3: 898.78 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 28-1 *D/T in Fridge:* 6/7/11 13:20

Impinger 2: *Bottle Number:* 28-2 *D/T in Fridge:* 6/7/11 13:20

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature]

OMNI-Test Laboratories, Inc.

Run Notes

Fuel weight = 180.0 lb

Client: ______
Model: ______
Project #: ______
Tracking #: ______
Run #: 29 Date: 6/7/11
Test Crew: A. Kravitz
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

40% of max burn

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

150 lbs. coal
(wet stoker)

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: N/A
DOOR: N/A
PRIMARY AIR: Auto (40%)

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

40% of max burn

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 6/7/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 6/7/11 *Run #:* 29 *Appliance/Fuel/Burn Rate:* Coal/Auger Fed OWHH - Hot Start

Filter Data

T1: *ID:* A7583406

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A751834V

Q2: *ID:* FNB 96

Q3: *ID:* FNB 97

Q4: *ID:* FNB 98 *Preliminary Weight:* .1522

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 6/7/11 17:50

Q4 weight record:			
D/T:	6/15/11	6/28/11	
Audit:	.5001	.5002	
Temp:	73.6	74.1	
Humidity:	8.6	10.9	
Weight (1):	.1516	.1518	
Weight (2):	N/A	N/A	

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .008 @ -10"

Box A: .011 @ -15"

Box B: .009 @ -10"

Flow Rate Check:

T1: 160.56 mL/min Q2: 1793.5 mL/min

Q1: ~~794~~ 1029.4 mL/min Q3: 194.06 mL/min

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .011 @ -15"

Box B: .006 @ -11"

Ammonia Sample:

Impinger 1: *Bottle Number:* 29-1 *D/T in Fridge:* 6/7/11

Impinger 2: *Bottle Number:* 29-2 *D/T in Fridge:* 6/7/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 6/7/11

OMNI-Test Laboratories, Inc.

Run Notes

Client: Fairbanks North Star Borough
Model: WHH Spruce Low
Project #: 477-S-1-1
Tracking #: ____
Run #: 30 Date: 6/30/11
Test Crew: A. Kravitz, S. Pulton, J. Clark
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Automatic (low burn)

SECONDARY: N/A

TERTIARY: N/A

FAN: On Low

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Cordwood

START UP PROCEDURES
BYPASS: Open during loading
FUEL LOADING: Done @ 2 min
DOOR: Closed @ 2 min
PRIMARY AIR: Auto

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Automatic (low burn)

SECONDARY: N/A

TERTIARY: N/A

FAN: On Low

Technician signature: [signature] Date: 6/30/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1
Date: 6/30/11 *Run #:* 30 *Appliance/Fuel/Burn Rate:* NQOWHH Spruce Low

Filter Data

T1: *ID:* A7583417
T1 (2): *ID:* N/A
Time Changed: N/A

Q1: *ID:* A7518315
Q2: *ID:* FNB 49
Q3: *ID:* FNB ~~100~~ 101
Q4: *ID:* N/A *Preliminary Weight:* N/A
Q4 (2): *ID:* N/A *Preliminary Weight:* N/A
Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
6/30/11 1636

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅
Ammonia Train: .010 @ -8"
Box A: .000 @ -12"
Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ∅
Box A: .014 @ -10"
Box B: N/A @ N/A

Flow Rate Check:

T1: 200.7 mL/min Q2: 1979.3 mL/min
Q1: 997.4 mL/min Q3: 985.86 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 30-1 *D/T in Fridge:* 6/30/11 1630
Impinger 2: *Bottle Number:* 30-2 *D/T in Fridge:* 6/30/11 1630

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 6/30/11

NQOWHH SPRUCE cow Run 30

118.1 lb
- 48.9 lbs

Preburn: 114.5 lb

12.3	14.1
10.3	12.9
12.3	14.9
10.2	12.9
15.2	15.9
14.4	
16.2	Avg = 14.00
14.8	
14.7	
14.9	
14.2	
16.1	
13.5	
16.1	
14.3	
16.4	
14.2	
12.9	
13.7	
15.4	
16.5	
11.4	
11.1	

OMNI-Test Laboratories, Inc.

Run Notes

Client: FNB
Model: NDOVHH Birch high
Project #: ______
Tracking #: ______
Run #: 31 Date: 7/1/11
Test Crew: AK, SB, JC
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: High heat draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Aut

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None ———					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Birch cordwood

START UP PROCEDURES
BYPASS: Closed @ 3:00
FUEL LOADING: Done @ 2:30
DOOR: Closed @ 3:00
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: High heat draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 7/1/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 7/1/11 *Run #:* 31 *Appliance/Fuel/Burn Rate:* NQOWHH Birch ~~Low~~ High

Filter Data

T1: *ID:* A7583390

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A768262E

Q2: *ID:* FNB 102

Q3: *ID:* FNB 103

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 7/1/11 1300

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅ @ 15"

Ammonia Train: .013 @ -18"

Box A: .011 @ -10"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ∅ @ 18"

Box A: .012 @ -18"

Box B: N/A @ N/A

Flow Rate Check:

T1: 211.3 mL/min Q2: 1984.6 mL/min

Q1: 997.4 mL/min Q3: 1088.7 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 31-1 *D/T in Fridge:* 7/1/11 1245

Impinger 2: *Bottle Number:* 31-2 *D/T in Fridge:* 7/1/11 1245

Technician Signature/Date: [signature] 7/1/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

NQOWHH Birch ~~Low~~ High Run 31

Test load = 100.4 lb

12.6	12.4
12.9	14.3
13.6	14.1
18.2	25.1
11.7	12.7
23.5	18.1
23.6	12.0
27.9	20.1
27.2	15.5
23.2	
14.5	
14.3	
22.6	
15.7	
14.5	
14.8	
19.8	
12.7	
23.2	
22.5	

AVG = 18.04

OMNI-Test Laboratories, Inc.

Run Notes

Client: Fairbanks North Star Borough
Model: NQ OWHH Birch Low
Project #: 477-S-1-1
Tracking #: ____
Run #: 32 Date: 7/6/11
Test Crew: AU, SB, JC
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Low heat draw

SECONDARY: ~~Fixed~~ N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Birch Cordwood

START UP PROCEDURES
BYPASS: Closed @ 2:30
FUEL LOADING: Done @ 2:00
DOOR: Closed @ 2:30
PRIMARY AIR: N/A
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Low heat draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 7/6/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 7/6/11 *Run #:* 32 *Appliance/Fuel/Burn Rate:* NQ OWHH Birch Low

Filter Data

T1: *ID:* A7583428

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A768261D

Q2: *ID:* FNB 104

Q3: *ID:* FNB 105

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 7/6/11 16:50

Q4 weight record:			
D/T:			
Audit:			
Temp:			
Humidity:			
Weight (1):			
Weight (2):			

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅ @ -15"

Ammonia Train: .009 @ -11"

Box A: .000 @ -15"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ∅ @ -15"

Box A: .008 @ -15"

Box B: N/A @ N/A

Flow Rate Check:

T1: 159.34 mL/min Q2: 1779.1 mL/min

Q1: 1030.9 mL/min Q3: 975.29 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 32-1 *D/T in Fridge:* 7/6/11 16:46

Impinger 2: *Bottle Number:* 32-2 *D/T in Fridge:* 7/6/11 16:40

Technician Signature/Date: [signature] 7/6/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run 32
NQOWHH Birch Low
7/6/11

Preburn: 102.0 lb
Test fuel: 100.2 lb

10.2	13.2
12.4	22.2
25.1	23.4
11.2	18.1
24.5	18.6
20.4	12.2
16.5	11.9
18.0	13.2
11.3	11.7
32.2	
31.0	AVG = 17.02
15.4	
12.1	
13.0	
11.3	
14.5	
13.2	
15.9	
15.0	
25.9	

Run Notes

Client: FNB
Model: NQ0WH/H Birch Low Cold Start
Project #: 477-S-01-1
Tracking #: ______
Run #: 33 Date: 7/8/11
Test Crew: AH, SB, JC
OMNI Equipment ID #(s): ______

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

Low Draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	See Attached					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Birch Cordwood

START UP PROCEDURES

BYPASS:
FUEL LOADING: See
DOOR:
PRIMARY AIR: Attached

OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Low Draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 7/8/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 7/8/11 *Run #:* 33 *Appliance/Fuel/Burn Rate:* NQ OWHH Birch Low Cold Start

Filter Data

T1: *ID:* A7583439

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A768260C + A768259J

Q2: *ID:* FNB 106 + 108 +110

Q3: *ID:* FNB 107 + 109

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 7/8/11 15:00

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅ @ -15"

Ammonia Train: .010 @ -13"

Box A: .011 @ -15"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ∅ @ -15"

Box A: .016 @ -16"

Box B: N/A @ N/A

Flow Rate Check:

T1: 145.4 mL/min Q2: 1903.8 mL/min

Q1: 980.6 mL/min Q3: 1018.3 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 33-1 *D/T in Fridge:* 7/8/11 14:40

Impinger 2: *Bottle Number:* 33-2 *D/T in Fridge:* 7/8/11 14:40

Technician Signature/Date: [signature] 7/8/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 44S

Run 33

NQ OWHH Cold Start

Kindling

40 lbs => load 20 lbs to start, Added Remaining 20 lbs @ 5 mins, bypass shut @ ~~[illegible]~~ 8 min

Preburn

100.2 lbs => loaded @ 22 min

Test Fuel => loaded @ 2:20

100.1 lb

12.3	19.9
28.4	28.1
27.4	17.4
25.1	30.9
24.6	26.1
30.1	35.0
13.2	24.4
18.0	32.9
32.9	34.1
29.1	32.4
32.1	
32.2	
34.7	
24.8	
25.2	
24.5	
22.3	

AVG = 26.78

Run Notes

Client: FNB
Model: EPA OWHH w/ Retrofit Catalyst
Project #: 411-S-01-1
Tracking #:
Run #: 34 Date: 1/27/11
Test Crew: AH, SB, JC
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Low draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Birch Cordwood

START UP PROCEDURES
BYPASS: Close @ 1:30
FUEL LOADING: Done @ 1:00
DOOR: Close @ 1:30
PRIMARY AIR: N/A
OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Low Draw

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

Technician signature: [signature] Date: 1/27/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 7/27/11 *Run #:* 34 *Appliance/Fuel/Burn Rate:* EPA OWHH w/ Birch Low Retrofit Catalyst

Filter Data

T1: *ID:* A758346C

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A7682752

Q2: *ID:* FNB 111

Q3: *ID:* FNB 112

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
7/27/11 22:30

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .008 @ -14"

Box A: .015 @ -20

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .015 @ -20

Box B: N/A @ N/A

Flow Rate Check:

T1: 180.3 mL/min Q2: 1910.3 mL/min

Q1: 1108.1 mL/min Q3: 946.9 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 34-1 *D/T in Fridge:* 7/27/11 22:15

Impinger 2: *Bottle Number:* 34-2 *D/T in Fridge:* 7/27/11 22:15

Technician Signature/Date: [signature] 7/27/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run 34 Fuel Data
Phase II Boiler w/ Retrofit Catalyst - Birch

Preburn weight : 101 lbs
Test Fuel Weight : 125 lbs

Moisture:

	33.7
	33.5
	32.1
	34.4
	35.4
	23.9
	19.8
	25.3
	19.7
	25.8
	29.1
	27.6
	30.8
	18.6
	28.1
AVG	27.90%

OMNI-Test Laboratories, Inc.

Run Notes

Client: Fairbanks Northstar Borough
Model: Coal Stove - Wet stoker Coal - High Burn
Project #: 477-S-1-1
Tracking #: 1684
Run #: 35 Date: 8/10/11
Test Crew: AH, SB
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1 full revolution open from finger tight

SECONDARY: N/A

TERTIARY: N/A

FAN: On High

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
90:00	—	—	—	-3.0 lb	—	—

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

stoker coal

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 1:30
DOOR: closed @ 3:00
PRIMARY AIR: Set @ 5:00

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

Technician signature: [signature] Date: 8/10/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/10/11 *Run #:* 35 *Appliance/Fuel/Burn Rate:* Coal Stove – Wet Stoker Coal -High

Filter Data

T1: *ID:* A758345B

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A768267J

Q2: *ID:* FNB 113

Q3: *ID:* FNB 114

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
8/10/11 18:30

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .010 @ 15"

Box A: .013 @ -20"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .015 @ -20"

Box B: N/A @ N/A

Flow Rate Check:

T1: 172.5 mL/min Q2: 1869.0 mL/min

Q1: 998.4 mL/min Q3: 939.2 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 35-1 *D/T in Fridge:* 18:45

Impinger 2: *Bottle Number:* 35-2 *D/T in Fridge:* 18:45

Technician Signature/Date: [signature]

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Adopted December 24, 2014

OMNI-Test Laboratories, Inc.

Run Notes

Client: Fairbanks North Star Borough
Model: Coal Stove/Wet Lump Coal/Low Burn/Cold Start
Project #: 477-S-1-1
Tracking #: 1684
Run #: 36 Date: 8/11/11
Test Crew: SB, JC, AK
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: 1/4 turn open from Fully closed

SECONDARY: N/A

TERTIARY: N/A

FAN: On High

~~PREBURN~~ Cold Start SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
0:00:08	Ash door cracked		+4.0-birch kindling			startup
0:03:30	Door open		4.5-coal		kindling leveled	Propane torch used
0:10:00	Door open		5-coal			
0:13:00	Door open		16.5-coal			
0:15:30	Door open					
~~0:25:00~~ 0:31:00	Doors closed					
1:47:00	Zeroed scale, loaded fuel		25-coal			

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Lump Coal (25.0 lb)

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done by 1:49:00
DOOR: Closed @ 1:54:00
PRIMARY AIR: set the whole time

OTHER: 2:27:00 - fire out, ash door opened

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: 1/4 turn open from Fully Closed

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

*Coals stirred @ 7:28:00 + @ 8:05:00

Technician signature: [signature] Date: 8/11/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/11/11 *Run #:* 36 *Appliance/Fuel/Burn Rate:* Coal Stove/Wet Lump Coal/Low Burn/Cold Start

Filter Data

T1: *ID:* ~~A768258E~~ A779727Z

T1 (2): *ID:* ______

Time Changed: ______

Date/time Samples placed in freezer/dessicator: 8/11/11 18:00

Q1: *ID:* A768258I

Q2: *ID:* FNB 116

Q3: *ID:* FNB 117

Q4: *ID:* N/A *Preliminary Weight:* ______

Q4 (2): *ID:* ______ *Preliminary Weight:* ______

Time Changed: ______

Q4 weight record:	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ∅

Ammonia Train: .010 @ -12"

Box A: .012 @ -15"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ∅

Box A: ∅ @ ______

Box B: N/A @ ______

Flow Rate Check:

T1: 162.85 mL/min Q2: 1847.8 mL/min

Q1: 1064.4 mL/min Q3: 1005.9 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 36-1 *D/T in Fridge:* 8/11 1800

Impinger 2: *Bottle Number:* 36-2 *D/T in Fridge:* 8/11 1800

Technician Signature/Date: [signature] 8/11/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Run Notes

Client: Fairbanks North Star Borough
Model: Coal Stove/Wet Lump Coal/ Low Burn/ Hot Start
Project #: 477-S-1-1
Tracking #: 1684
Run #: 37 Date: 8/12/11
Test Crew: SB, JC, AK
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY:

1/4 open from fully closed

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Wet lump coal
25.0 lb

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 1:00
DOOR: closed @ 9 Minutes
PRIMARY AIR: Set @ 9 min
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY:

Same as above

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

Stirred coals @ 5:49:00

Technician signature: [signature] Date: 8/12/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/12/11 *Run #:* 37 *Appliance/Fuel/Burn Rate:* Coal Stove/Wet Lump Coal/Low Burn/Hot Start

Filter Data

T1: *ID:* A7797264

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A768266I

Q2: *ID:* FNB #118

Q3: *ID:* FNB #119

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
8/12/11 17:00

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ϕ

Ammonia Train: .015@ -17

Box A: .008 @ -16"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ϕ

Box A: .011 @ -10

Box B: N/A @ N/A

Flow Rate Check:

T1: 247.3 mL/min Q2: 1881.7 mL/min

Q1: 1002.9 mL/min Q3: 1046.5 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 37-1 *D/T in Fridge:* 17:00

Impinger 2: *Bottle Number:* 37-2 *D/T in Fridge:* 17:00

Technician Signature/Date: [signature] 8/12/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

OMNI-Test Laboratories, Inc.

Run Notes

1) 0.010 1) 0.031
2) 0.026 2) 0.034
3) 0.032 3) 0.034
4) 0.034 4) 0.033
5) 0.034 5) 0.031
6) 0.036 6) 0.024
static = 0.107

Client: FNB
Model: Dry Lump Coal Hot Start
Project #: 477-S-01-1
Tracking #: 1684
Run #: 38 Date: 8/15/11
Test Crew: AK, JC
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: 1/4 turn open

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
None						

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Dry lump coal
29.0 lb

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING: Done @ 1:00
DOOR: Closed @ 5:00
PRIMARY AIR: Set the whole time
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: 1/4 turn open

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

5:60 - stirred coals

Technician signature: [signature] Date: 8/15/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/15/11 *Run #:* 38 *Appliance/Fuel/Burn Rate:* Dry Lump Coal Hot Start

Filter Data

T1: *ID:* A7797280

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A7682654

Q2: *ID:* FNB 120

Q3: *ID:* FNB 121

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator:
8/15/11 1815

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: 0

Ammonia Train: .015@-15"

Box A: .012 @ -15"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: 0

Box A: .015 @ -15"

Box B: N/A @ N/A

Flow Rate Check:

T1: 170.90 mL/min Q2: 1883.7 mL/min

Q1: 990.81 mL/min Q3: 1053.5 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 38-1 *D/T in Fridge:* 8/15

Impinger 2: *Bottle Number:* 38-2 *D/T in Fridge:* 8/15

Technician Signature/Date: [signature] 8/15/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Adopted
OMNI-Test Laboratories, Inc.

December 24, 2014

* Kindling: ~~6.0~~ Birch 6.0 lb
Preburn = 25.0 lb coal
Test = 25.0 lb coal

Run Notes

Client: FNB wet Stoker
Model: ~~Dry Lump~~ Coal Cold Start
Project #: 477-S-01-1
Tracking #: 1684
Run #: 39
Date: 8/16/11
Test Crew: AH, JC
OMNI Equipment ID #(s):

* lit using propane torch
↳ 0:00:00 to 0:02:00

* Q2 replaced 1:13:00

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: 1/4 turn open

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
0:04:30	—	—	11.0	—	—	Ash door open
0:12:00	—	—	14.0	—	—	Ash door open
0:18:00	Ash door closed, primary set	—	—	—	—	—
1:25:00	Test fuel loaded					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Stoker Coal
25.0 lb

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done by 1:28:06
DOOR: Closed @ 1:30:00
PRIMARY AIR: set for whole run

OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: 1/4 turn open

SECONDARY: N/A

TERTIARY: N/A

FAN: On high

5:45:00 - Stirred coals

Technician signature: [signature] Date: 8/16/11

Control No. P-SFAK-0007.doc, Effective date: 05/09/2008

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/16/11 *Run #:* 39 *Appliance/Fuel/Burn Rate:* ~~Dry lump~~ Wet Stoker coal cold start

Filter Data

T1: *ID:* A779725X

T1 (2): *ID:* ____

Time Changed: ____

Q1: *ID:* A768264G + A768263P

Q2: *ID:* FUB 122

Q3: *ID:* FNB 123

Q4: *ID:* N/A *Preliminary Weight:* ____

Q4 (2): *ID:* N/A *Preliminary Weight:* ____

Time Changed: ____

Date/time Samples placed in freezer/dessicator: 8/16/11 1700

Q4 weight record:			
D/T:			
Audit:			
Temp:			
Humidity:			
Weight (1):			
Weight (2):			

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: ϕ

Ammonia Train: .006@ .17"

Box A: .010 @ -15"

Box B: N/A @ N/A

Post-Test Leaks:

Gas Analyzer Train: ϕ

Box A: .009 @ -15"

Box B: NA @ NA

Flow Rate Check:

T1: 148.37 mL/min Q2: 1940.1 mL/min

Q1: 1583.7 mL/min Q3: 1048.0 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 39-1 *D/T in Fridge:* 8/16

Impinger 2: *Bottle Number:* 39-2 *D/T in Fridge:* 8/16

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 8/16/11

Run Notes

Client: FNB
Model: No 1 Heating Oil 2`
Project #: 477-S-01-1
Tracking #: 1635
Run #: 40 Date: 8/17/11
Test Crew: AA, JC
OMNI Equipment ID #(s):

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: Auto

SECONDARY: N/A

TERTIARY: N/A

FAN: Auto

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
	None					

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

No. 1 Fuel oil

START UP PROCEDURES
BYPASS: N/A
FUEL LOADING:
DOOR:
PRIMARY AIR:

OTHER:

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)
PRIMARY: Auto

SECONDARY: NA

TERTIARY: NA

FAN: Auto

Technician signature: [signature] Date: 8/17/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/17/11 *Run #:* 40 *Appliance/Fuel/Burn Rate:* No. 1 Heating Oil 2

Filter Data

T1: *ID:* A779724W

T1 (2): *ID:* N/A

Time Changed: NA

Q1: *ID:* A768268K

Q2: *ID:* FNB 124

Q3: *ID:* FNB 125

Q4: *ID:* N/A *Preliminary Weight:*

Q4 (2): *ID:* N/A *Preliminary Weight:*

Time Changed:

Date/time Samples placed in freezer/dessicator: 8/18/11 0800

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: Ø

Ammonia Train: .014 @ -14"

Box A: .004 @ -15"

Box B: NA @ NA

Post-Test Leaks:

Gas Analyzer Train: Ø

Box A: .012 @ -15"

Box B: NA @ NA

Flow Rate Check:

T1: 1415.29 mL/min Q2: 1880.0 mL/min

Q1: 1020.9 mL/min Q3: 974.93 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 40-1 *D/T in Fridge:* 8/18

Impinger 2: *Bottle Number:* 40-2 *D/T in Fridge:* 8/18

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 8/17/11

Run Notes

A propane torch used for startup.

Client: FNB
Model: EPA Stove Birch Low Cold Start
Project #: 477-S-01-1
Tracking #: ____
Run #: 41 Date: 8/18/11
Test Crew: AK, JC
OMNI Equipment ID #(s): ____

PREBURN

DESCRIBE OR SKETCH AIR OR THERMOMSTAT SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCABLE)

PRIMARY: 1/4" open from fully close

SECONDARY: Fixed

TERTIARY: N/A

FAN: N/A

PREBURN SETTINGS AND ACTIVITIES

TIME	AIR (THERMO) CHANGES PRIMARY/SECONDARY/TERTIARY	FAN SETTING CHANGE	ADD FUEL + WT.	ADD FUEL - WT.	RAKE COAL	COMMENT
0:00:00	—	—	16.0	—	—	kindling
0:15:00	—	—	16.5	—	—	Preburn
0:18:00	Forced combustion air applied	—	—	—	—	—
0:23:00	Door closed, primary opened wide	—	—	—	—	—
0:40:00	Primary reduced to test setting	—	—	—	—	—
1:21:00	—	—	—	—	Stirred coals	—
1:50:00	Test fuel loaded	—	—	—	—	—

TEST

TEST FUEL CONFIGURATION SKETCH
(INDICATE VIEW ANGLE)

Birch cordwood

START UP PROCEDURES

BYPASS: N/A
FUEL LOADING: Done by 1:51:00
DOOR: Closed @ 1:51:30
PRIMARY AIR: Set @ 1:55:00
OTHER: N/A

DESCRIBE OR SKETCH TEST SETTINGS BELOW:
(SETTINGS MUST BE ACCURATE AND REPRODUCIBLE)

PRIMARY: 1/4" open from fully closed

SECONDARY: Fixed

TERTIARY: N/A

FAN: N/A

Technician signature: [signature] Date: 8/17/11

Client: Fairbanks North Star Borough
Project #: 477-S-01-1

Date: 8/18/11 *Run #:* 41 *Appliance/Fuel/Burn Rate:* EPA Stove Birch Low Cold Start

Filter Data

T1: *ID:* A779121T

T1 (2): *ID:* N/A

Time Changed: N/A

Q1: *ID:* A76826AL

Q2: *ID:* FNB 126

Q3: *ID:* FNB 127

Q4: *ID:* N/A *Preliminary Weight:* N/A

Q4 (2): *ID:* N/A *Preliminary Weight:* N/A

Time Changed: N/A

Date/time Samples placed in freezer/dessicator: 8/18/11 1600

Q4 weight record:			
	D/T:	D/T:	D/T:
	Audit:	Audit:	Audit:
	Temp:	Temp:	Temp:
	Humidity:	Humidity:	Humidity:
	Weight (1):	Weight (1):	Weight (1)
	Weight (2):	Weight (2):	Weight (2)

N/A

Supplementary Data

Pre-Test Leaks:

Gas Analyzer Train: 0

Ammonia Train: .007 @ -17"

Box A: .001 @ -14"

Box B: NA @ NA

Post-Test Leaks:

Gas Analyzer Train: 0

Box A: .006 @ -14"

Box B: NA @ NA

Flow Rate Check:

T1: 2024.7 mL/min Q2: 1976.7 mL/min

Q1: 1022.3 mL/min Q3: 1041.5 mL/min

Ammonia Sample:

Impinger 1: *Bottle Number:* 41-1 *D/T in Fridge:* 8/8/11

Impinger 2: *Bottle Number:* 41-1 *D/T in Fridge:* 8/18/11

OMNI Equipment: 23, 131, 343, 419, 289, 371, 372, 445

Technician Signature/Date: [signature] 8/18/11

FUEL DATA

Client: FNB
Model: EPA Stove Birch Low Cold Start
Project #: 477-S-01-1 Tracking #: ____
Date: 8/18/11 Test Crew: AH, JC Run #: 41
OMNI Equipment ID #: 183, 431
FUEL LOAD PREPARED BY: AH
FUEL: ~~DOUGLAS-FIR SPECIES, UNTREATED, AIR-DRIED, STANDARD GRADE OR BETTER, DIMENSIONAL LUMBER.~~ Birch Cordwood

PRE-BURN FUEL
MOISTURE CONTENT (METER -- DRY BASIS)

Kindling: 6.0 lb
Preburn: 16.5 lb

CALIBRATION: Cal Value (1) = 12% Actual Reading 12.0
Cal Value (2) = 22% Actual Reading 22.0

Piece	Length	Readings			Type
1	____ ft	13.7	18.9	16.7	cord
2	____ ft	24.1	16.3	19.0	↓
3	____ ft	15.7	13.2	13.1	↓

Length of cut pieces: 12-20 inches Pre-Burn Fuel Average Moisture:

Time (clock): 1000 Room Temperature (F): 73 Initials: AH

TEST FUEL

FUEL TYPE AND AMOUNT: 2 × 4 N/A 4 × 4 N/A
CALCULATED LOAD WEIGHT: N/A ACTUAL LOAD WEIGHT: N/A (2 × 4)
(4 × 4)
16.4 lb Total
FUEL PIECE LENGTH: 12-20"

MOISTURE CONTENT (METER -- DRY BASIS)

PIECE	READINGS			TYPE
1	15.2	15.1	16.6	cord
2	14.2	24.7	25.1	↓
3	14.3	14.8	15.2	↓
4	20.5	21.2	20.6	↓
5	13.2	13.1	14.7	↓
6	12.8	19.4	20.6	↓
7				
8				
9				
10				

OVERALL TEST FUEL LOAD MOISTURE AVERAGE: ~~17.54~~ 17.25 Coverall

Time (clock): 1000 Room Temperature (F): 73 Initials: AH

Technician signature: [signature] Date: 8/18/11

Coal Moisture worksheet

"Wet" Stoker Coal

Beaker: 527

Tare: 137.7 grams

5/9/11 Initial weight: 329.4 grams

5/12/11 Final weight: 281.3 grams

Initial weight = 329.4 - 137.7
=> 191.7 grams

Final weight => 281.3 - 137.7
=> 143.6 grams

DB Moisture =>

$$\frac{191.7 - 143.6}{143.6} \Rightarrow \boxed{33.5\%}$$

[signature] 5/12/11

Dry Stoker coal

Beaker: 499

Tare: 136.0 grams

5/9/11 Initial weight: 391.3 grams

5/12/11 Final weight: 365.5 grams

Initial weight = 391.3 - 136
=> 255.3 grams

Final weight = ~~391.3~~
365.5 - 136
=> 229.5

DB Moisture =>

$$\frac{255.3 - 229.5}{229.5} \Rightarrow \boxed{11.2\%}$$

Coal Moisture ~~8/10/11~~ 8/31/11

Dry Lump

Beaker: 457	Initial: 232.4	216.1	9/1 0830
Tare: 130.3	In oven: 8/31/11 10:00	216.2	9/1 1430

Wet Lump

Beaker: 2062	Initial: 272.5	241.5	9/1 0830
Tare: 119.5	In oven: 8/31/11 10:00	241.5	9/1 1430

Dry Stoker (Batch 2)

Beaker: 583	Initial: 222.8	208.7	9/1 0830
Tare: 131.1	In oven: 8/31/11 10:00	208.6	9/1 1430

Dry Lump: $\frac{(232.4-130.3)-(216.1-130.3)}{216.1-130.3} = 19.00\%$

Wet Lump = 25.41%

Dry Stoker: 18.32%

[signature] 9/1/11

Measurement of Space-Heating Emissions

Appendix F

Photographs

F.1 EPA Certified Wood Stove

Run 2 (birch high) test fuel

Run 2 test fuel loaded

Run 3 (spruce high) test fuel

Run 3 test fuel loaded

Run 5 (birch low) test fuel

Run 5 test fuel loaded


Run 6 (spruce low) test fuel


Run 6 test fuel loaded


Run 41 (birch low, cold start) fuel


Run 41 kindling loaded


Run 41 preburn loaded


Run 41 test fuel loaded

F.2 Conventional Wood Stove

Run 12 (spruce high) test fuel

Run 12 test fuel loaded

Run 13 (birch high) test fuel

Run 13 test fuel loaded

Run 14 (spruce low) test fuel

Run 14 test fuel loaded


Run 15 (birch low) test fuel


Run 15 test fuel loaded

F.3 EPA Phase II Certified OWHH

Run 8 (birch high) test fuel

Run 8 test fuel loaded

Run 9 (birch low) test fuel

Run 9 test fuel loaded

Run 10 (spruce high) test fuel

Run 10 test fuel loaded

Run 11 (spruce low) test fuel

Run 11 test fuel loaded

Run 34 (birch low, with retrofit catalyst) test fuel

Run 34 test fuel loaded

F.4 Coal Stove

Run 20 (dry stoker coal high) test fuel

Run 20 test fuel loaded

Run 21 (dry stoker coal low) test fuel

Run 21 test fuel loaded

Run 23 (wet stoker coal low) test fuel

Run 23 test fuel loaded

Run 35 (wet stoker coal high) test fuel

Run 35 test fuel loaded

Run 36 (wet lump coal low, cold start) test fuel-kindling, preburn, test fuel

Run 36 kindling/preburn loaded

Run 36 test fuel loaded

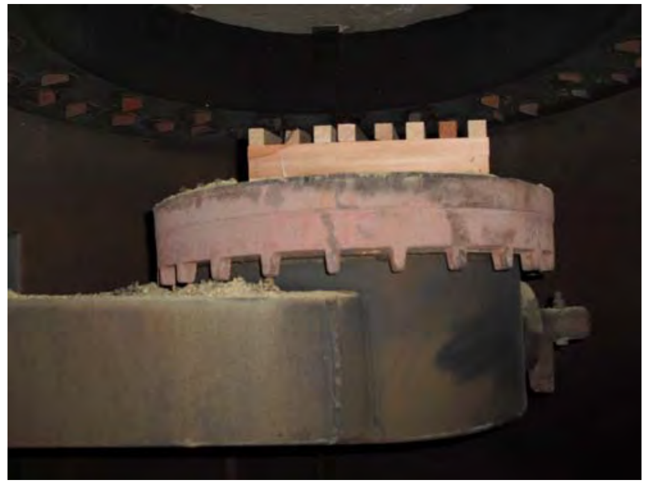
Run 37 (wet lump coal low) test fuel loaded

Run 38 (dry lump coal low) test fuel loaded

Run 39 (wet stoker coal low, cold start) test fuel loaded

F.5 Auger-fed Coal Hydronic Heater


Run 28 (cold start) kindling


Run 28 kindling on burner


Auger-fed HH hopper installation

F.6 Non-qualified OWHH


Run 25 (spruce high) test fuel


Run 25 test fuel loaded


Run 30 (spruce low) test fuel


Run 30 test fuel loaded


Run 31 (birch high) test fuel


Run 31 test fuel loaded


Run 32 (birch low) test fuel


Run 32 test fuel loaded


Run 33 (birch low, cold start) kindling loaded


Run 33 preburn loaded


Run 33 test fuel


Run 33 test fuel loaded

Measurement of Space-Heating Emissions

Appendix G

Equipment Calibration Documentation

Equipment Item	Equipment Number	Calibration Period
2000mg Balance	23	6 months
500mg Weight	131	5 years
10lb Weight	132	5 years
Delmhorst Wood Moisture Meter	183	Prior to use
APEX Sample Box	289	6 months
Omega Thermohygrometer	291	1 year
ThermoScientific CO PPM Analyzer	325	Prior to use
ThermoScientific VOC Analyzer	328	Prior to use
ThermoScientific SO2 Analyzer	329	Prior to use
Weightronix 500 lb Scale	353	Prior to use
Weightronix 5000 lb Scale	356	Prior to use
APEX Sample Box	371	6 months
California Analytic O2, CO2, CO % Analyzer	419	Prior to use
Delmhorst Moisture Meter Calibrator	431	6 months
Bios Air Flow Meter	445	1 year
Delmhorst Wood Moisture Meter	507	Prior to use
ThermoScientific NOx Analyzer	509	Prior to use

Adopted

Certificate of Calibration

December 24, 2014

Certificate Number: **477037**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

OnSite

0723.01

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

PO: TBD
Order Date: 5/16/2011
Authorized By: N/A

Property #: OMNI-00023
User: N/A
Department: N/A
Make: Mettler
Model: AE200
Serial #: E17657
Description: Scale 205g
Procedure: DCN 500818/500887
Accuracy: ±0.0004g ±1 LSD

Calibrated on: 5/16/2011
*Recommended Due: 11/16/2011
Environment: 25 °C 36 % RH
As Received: Out of Tolerance
As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 53

Remarks: * Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
503A	Rice Lake	1mg-200g (Class O)	Mass Set	11/8/2011	460936

Measurement Data

Before — × = OOT condition — Accredited = ✓

Force

Parameter / Measurement Description	Range	Unit	Reference	UUT	Variance	Min	Max	Uncertainty	
		mg	1.00	1.0	0.00	0.50	1.50	2.6E-6	✓
		mg	10.00000	10.0000	0.00000	9.99950	10.00050	2.6E-6	✓
		mg	100.00000	100.0000	0.00000	99.99950	100.00050	2.6E-6	✓
		mg	500.00000	500.0000	0.00000	499.99951	500.00049	2.6E-6	✓
		g	1.00000	1.0000	0.00000	0.99950	1.00050	2E-6	✓
		g	20.00000	20.0002	-0.00020	19.99950	20.00050	2E-6	✓
		g	50.00000	50.0004	-0.00040	49.99950	50.00050	2E-6	✓
		g	100.00000	100.0006 ×	-0.00060	99.99950	100.00050	2E-6	✓
		g	150.00000	150.0007 ×	-0.00070	149.99950	150.00050	2E-6	✓
		g	185.00000	185.0009 ×	-0.00090	184.99950	185.00050	2E-6	✓
		g	200.00000	200.0009 ×	-0.00090	199.99950	200.00050	2E-6	✓

After — Accredited = ✓

Parameter / Measurement Description	Range	Unit	Reference	UUT	Variance	Min	Max	Uncertainty	
		g	20.00000	20.0000	0.00000	19.99950	20.00050	2E-6	✓
		g	50.00000	50.0000	0.00000	49.99950	50.00050	2E-6	✓
		g	100.00000	100.0000	0.00000	99.99950	100.00050	2E-6	✓
		g	150.00000	150.0000	0.00000	149.99950	150.00050	2E-6	✓
		g	185.00000	185.0000	0.00000	184.99950	185.00050	2E-6	✓
		mg	1.00	1.0	0.00	0.50	1.50	2.6E-6	✓
		mg	10.00000	10.0000	0.00000	9.99950	10.00050	2.6E-6	✓
		mg	100.00000	100.0000	0.00000	99.99950	100.00050	2.6E-6	✓
		mg	500.00000	500.0000	0.00000	499.99951	500.00049	2.6E-6	✓
		g	1.00000	1.0000	0.00000	0.99950	1.00050	2E-6	✓
		g	200.00000	200.0000	0.00000	199.99950	200.00050	2E-6	✓

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without prior written consent of JJ Calibrations, Inc.
JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Reviewer 5 Issued 5/16/2011 Rev # 14 Cynthia Calcote Inspector

Adopted December 24, 2014

Certificate of Calibr...ion

Certificate Number: **413631**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

PO: **OTL-08-490**
Order Date: 11/04/2008

0723.01

Property #: OMNI-00131
User:
Department:
Make: Ohaus
Model: 500mg
Serial #: 27503
Description: 500mg WEIGHT
Procedure: DCN 500901
Accuracy: CLASS F

Calibrated on: 11/05/2008
*Recommended Due: 11/05/~~2009~~ 2013
Environment: 18 °C 43 % RH
As Received: Within Tolerance
As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 92

Remarks:

Refer to attachment for measurement results.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
256A	Rice Lake	W0133K	WEIGHT SET	02/08/2010	406054
432A	Sartorius	C-44	Microbalance 5.1g	11/13/2008	384448

* Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without prior written consent of JJ Calibrations, Inc. JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Reviewer

Inspector

5 Issued 11/05/2008 Rev # 13
G3

Adopted

Supplemental Calibration Report

Certificate Number: **413631**

December 24, 2014

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Customer:	Omni-Test Laboratories		
Property ID:	OMNI-00131	PO:	OTL-08-490
Make:	Ohaus	Order Date:	11/04/2008
Model:	500mg	Procedure:	DCN 500901
Serial #:	27503	Calibrated on:	11/05/2008
Description:	500mg WEIGHT	Technician:	92

Accredited = ✓

Parameter Measurement Description	Range	Unit	Reference	UUT	Variance	Min	Max	Uncertainty	
Before/After									
Mass									
		mg	500.0000	500.123	-0.1230	499.28	500.72	0.00011	✓

OMNI Environmental Services, Inc.
OMNI-Test Laboratories, Inc.
Beaverton, OR Phone (503) 643-3788

SCALE WEIGHT CALIBRATION DATA SHEET

Weight to be calibrated: 132

ID Number: 132

Standard Calibration Weight: 274

ID Number: 274

Scale Used: ~~185~~ 288

ID Number: ~~185~~ 288

Date: 2-07-08 By: K. Morgan

Standard Weight (A) (Lb.)	Weight Verified (B) (Lb.)	Difference (A - B)	% Error
10.0	10.0	Ø	Ø

*Acceptable tolerance is 1%.

This calibration is traceable to NIST using calibrated standard weights.

Technician signature: K. Morgan Date: 2-07-08

Thermal Metering System Calibration
Y and dH@

Manufacturer: APEX
Model: Model 533
Serial Number: NA
OMNI Tracking No.: 289

Previous Calibration Comparision

Date	10/8/2010	Acceptable	
dH@ Value	NA	Deviation (5%)	Deviation
y Factor	0.99	0.0495	0.000
Acceptance	Acceptable		

Average Orifice Meter dH@	Average Gas Meter y Factor
3.006	0.990

Calibration Date: 04/12/11
Calibrated by: S. Button
Calibration Frequency: 6 months
Next Calibration Due: 10/11/11
Instrument Range: 1.000 cfm
Standard Temp.: 68 oF
Standard Press.: 29.92 "Hg
Barometric Press.: 30.24 "Hg
Signature/Date: [signature] ~~4/12/11~~ 4/12/11 SB

4/29/11 SB (MY MISTAKE WRONG PAPER)

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.005
Acceptable dH@ Deviation	0.200
Maximum dH@ Deviation	1.838
Acceptance	~~Out of Limits~~ N/A SB

Reference Standard *		
Standard Calibrator	Model	Standard Test Meter
	S/N	1
	Calib. Date	17-Jun-10
	Calib. Value	0.9980 y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Vacuum ("Hg)	0.00	0.00	0.00
dH ("H2O)	2.57	1.44	0.67
Initial Reference Meter	133.515	139.512	146.685
Final Reference Meter	139.355	146.535	154.225
Initial DGM	0	0	0
Final DGM	5.883	7.09	7.705
Temp. Ref. Meter (°F), Tr	69.0	69.0	69.0
Temperature DGM (°F), Td	73.0	73.0	74.0
Time (Minutes)	7.0	11.5	27.3
Net Volume Ref. Meter, Vr	5.840	7.023	7.540
Net Volume DGM, Vd	5.883	7.09	7.705
Gas Meter y Factor =	0.992	0.993	0.984
Gas Meter y Factor Deviation (from avg.)	0.002	0.003	0.005
Orifice dH@	2.04	2.13	4.84
Orifice dH@ Deviation (from avg.)	0.966	0.873	1.838

where:

1. Deviation = |Average value for all runs - current run value|
2. y = [Vr x (y factor (ref)) x (Pb) x (Td + 460) / [Vd x (Pb + (dH / 13.6)) x (Tr + 460]
3. dH@ = 0.0317 x dH / (Pb (Td + 460)) x [(Tr + 460) x time) / Vr]^2

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET
0-0.25" Magnehelic Gauge

Range: 0-0.25" WC

ID Number: 289B (Stack draft)

Calibration Instrument: ~~Microtector~~ Digital Manometer

ID Number: OMNI- 315

Date: 4/29/2011

By: Aaron Kravitz

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer (A) ("WC)	Magnehelic Gauge (B) ("WC)	Difference (A - B)	% Error of Full Span*
0.00 - 0.05	.036	.039	-.003	1.2%
0.05 - 0.10	.090	.095	-.005	2%
0.10 - 0.15	.135	.141	-.006	2.4%
0.15 - 0.20	.157	.155	.002	0.8%
0.20 - 0.25	.214	.211	.003	1.2%

*Acceptable tolerance is 4%.

The uncertainty of measurement is ±0.01" WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: [signature] Date: 4/29/11

Reviewed by: [signature] Date: 4/29/11

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET
0-0.25" Magnehelic Gauge

Range: 0-0.25" WC

ID Number: 289D

Calibration Instrument: Microtector

ID Number: OMNI- ~~B~~ 315

Date: 4/29/2011

By: Aaron Kravitz

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer (A) ("WC)	Magnehelic Gauge (B) ("WC)	Difference (A - B)	% Error of Full Span*
0.00 - 0.05	~~.205~~ AK .048	~~.202~~ AK .042	.006	2.4%
0.05 - 0.10	.090	.092	-.002	0.8%
0.10 - 0.15	.117	.116	.001	0.4%
0.15 - 0.20	.180	.185	-.005	2.0%
0.20 - 0.25	.205	.202	.003	1.2%

*Acceptable tolerance is 4%.

The uncertainty of measurement is ±0.01" WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: [signature] Date: 4/29/11

Reviewed by: [signature] Date: 4/29/11

Temperature Calibration EPA Method 28 and 5G						
Booth:	**Temperature Monitor Type:**				**Identification Number:**	
Emissions 2	National Instruments				289C/Booth 2	
Reference Temperature Monitor Type:				**Identification Number:**		
OMEGA Calibrator Model CL20				OMNI- 117		
Calibration Performed By:	**Date:**	**Ambient Temperature:**		**Barometric Pressure:**		
Aaron Kravitz	4/29/2011	70		30.43		
Reference Point Source	**Temperature Monitor (EF)**					
		Method 5G Dilution Tunnel				
OMEGA Thermocouple Simulator Serial 117	**Method 28 Room**	**Meter (Tm)**	**Filters (Tf)**	**Tunnel (Tt)**	**Stack (Ts)**	**DB**
0	-2	-3	-1	-3	-1	
100	99	99	101	99	101	
300	299	299	299	299	299	
500	499	499	497	499	497	
700	699	699	695	699	695	

OMEGA Thermocouple Simulator Serial 117	Top	Bottom	Back	Left	Right
0	-3	-3	-3	-3	-3
100	99	99	99	99	99
300	299	299	299	299	299
500	499	499	499	499	499
700	699	699	699	699	699

[signature] 4/29/11

Adopted
Certificate of Calibration

Certificate Number: **466279**

December 24, 2014

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

0723.01

PO: OTL-10-085
Order Date: 12/20/2010
Authorized By: N/A

Property #: OMNI-00291
User: N/A
Department: N/A
Make: Omega
Model: RH82
Serial #: 9190156
Description: Thermohygrometer
Procedure: DCN 401013/403410
Accuracy: REFER TO SPECIFICATIONS

Calibrated on: 12/22/2010
*Recommended Due: 12/22/2011
Environment: 22 °C 35 % RH
As Received: Within Tolerance
As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 112

Remarks: * Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
464A	General Eastern	M4-RH/D2	HUMIDITY STANDARD	03/21/2011	448210
497A	Hart Scientific	1502A	Precision Digital Thermometer	09/14/2011	459710
601A	Burns Engineering	200G05B085	INDUSTRIAL PRT	02/03/2012	444255

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	UUT	Variance	Min	Max	Uncertainty	
Before/After									Accredited = ✓
Relative Humidity									
		%	25.00	25.3	-0.30	22.00	28.00	2.03	✓
		%	50.0	51	-1.0	47.0	53.0	2.03	✓
		%	75.00	76.5	-1.50	72.00	78.00	2.03	✓
Temperature									
		°F	50.00	50.2	-0.20	48.20	51.80	1.2	✓
		°F	66.50	66.5	0.00	64.70	68.30	1.2	✓

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without prior written consent of JJ Calibrations, Inc. JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Carolyn J Johansen
Reviewer

5 Issued 12/28/2010 Rev # 14

Inspector

Thermal Metering System Calibration
Y and dH@

Manufacturer:	Apex
Model:	XC-60-EP
Serial Number:	371
OMNI Tracking No.:	371

Previous Calibration Comparision

Date	7/14/2010	Acceptable	
dH@ Value	n/a	Deviation (5%)	Deviation
y Factor	0.996	0.0498	0.011
Acceptance	Acceptable		

Average Orifice Meter dH@	Average Gas Meter y Factor
1.408	1.007

Calibration Date:	02/15/11
Calibrated by:	S Button
Calibration Frequency:	6 Month
Next Calibration Due:	08/16/11
Instrument Range:	1.000 cfm
Standard Temp.:	68 oF
Standard Press.:	29.92 "Hg
Barometric Press.:	29.72 "Hg
Signature/Date:	[signature] 2/15/11

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.019
Acceptable dH@ Deviation	0.200
Maximum dH@ Deviation	0.067
Acceptance	Acceptable

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	1	
	Calib. Date	17-Jun-10	
	Calib. Value	0.9980	y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Vacuum ("Hg)	0.00	0.00	0.00
dH ("H2O)	1.30	0.65	0.30
Initial Reference Meter	115.04	120.643	127.695
Final Reference Meter	120.138	127.375	133.255
Initial DGM	0	0	0
Final DGM	5.072	6.781	5.407
Temp. Ref. Meter (°F), Tr	69.0	69.0	69.0
Temperature DGM (°F), Td	70.0	71.0	69.0
Time (Minutes)	7.0	13.5	15.8
Net Volume Ref. Meter, Vr	5.098	6.732	5.560
Net Volume DGM, Vd	5.072	6.781	5.407
Gas Meter y Factor =	1.002	0.993	1.025
Gas Meter y Factor Deviation (from avg.)	0.005	0.014	0.019
Orifice dH@	1.39	1.48	1.36
Orifice dH@ Deviation (from avg.)	0.022	0.067	0.045

where:

1. Deviation = |Average value for all runs - current run value|
2. y = [Vr x (y factor (ref)) x (Pb) x (Td + 460) / [Vd x (Pb + (dH / 13.6)) x (Tr + 460]
3. dH@ = 0.0317 x dH / (Pb (Td + 460)) x [(Tr + 460) x time) / Vr]^2

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET
0-1" Magnehelic Gauge

Range: 0-1" WC ID Number: 371 (B)

Calibration Instrument: Digital Manometer (A) ID Number: OMNI- 315

Date: 2/16/11 By: J. Button

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer (A) ("WC)	Magnehelic Gauge (B) ("WC)	Difference (A - B)	% Error of Full Span*
0.0 – 0.2	.06	.07	.01	1%
0.2 – 0.4	.31	.33	.02	2%
0.4 – 0.6	.55	.57	.02	2%
0.6 – 0.8	.64	.66	.02	2%
0.8 – 1.0	.92	.93	.01	1%

*Acceptable tolerance is 4%.

The uncertainty of measurement is ±0.1" WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: [signature] Date: 2/16/11

Reviewed by: ______ Date: ______

OMNI Environmental Services, Inc.
OMNI-Test Laboratories, Inc.
Beaverton, OR Phone (503) 643-3788

Thermocouple Readout Calibration Log

Date: 5-4-07 OMNI Meter Identification Number: OMNI- 00371 (A) Technician: B. Dows

		Meter Response						Acceptable?		
		0	200	400	600	800	1000			
Date	Calibration Meter ID		± 3EF*	± 6EF	± 9EF	± 12EF	± 15EF	Yes	No	Initials
5-4-07	290	-1	201	399	602	803	1002	✓		[illegible]
10-24-07	373	001	199	398	599	800	1001	✓		BR
5-01-08	373	002	200	397	596	796	996	✓		[illegible]
11-11-08	373	001	200	399	599	798	1000	✓		[illegible]
6/15/09	373	003	201	390	596	796	995	✓		SB
11/20/09	373	002	202	400	601	802	1002	✓		WO
5/17/10	373	1	201	401	601	801	1001	✓		SB
7/14/10	373	001	201	401	602	802	1001	✓		SB
2/15/11	373	001	201	401	601	802	1001	✓		SB
9/9/11	433	003	202	401	602	803	1003	✓		[illegible]
10/6/11	433	003	203	402	602	802	1001	✓		[illegible]

*Note: Acceptance Criteria are based on EPA Method 2 Section 4.3 (1.5% agreement of readings)

Technician signature: ______________________ Date: ____________

WOOD MOISTURE CONTENT CALIBRATION WORKSHEET

Moisture Content Standard OMNI ID #: OMNI-00431 (SHOP)

Reference Moisture Content Standard: **OMNI # 00430**

Date	Temp.	Barometric Pressure	Fixed Moisture %	Fixed Moisture %	Observed Moisture % (#431)	Observed Moisture % (#430)	Initials
4/29/11	72	30.3	22%	12%	22% / 12%	22% / 12%	SW
8/10/11	85	29.2	22%	12%	22% / 12%	22% / 12%	SW
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
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			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			
			22%	12%			

Notes: ______________________

Technician signature: [signature] Date: 4/29/11

NVLAP®
NVLAP Lab Code 200661

Bios
Driving a Higher Standard in Flow Measurement℠

Calibration Certificate

Certificate No.	507987
Product	Defender 530 Medium Flow
Serial No.	120662
Cal. Date	9/7/2010
Sales Date	9/23/2010 *Calibration interval commences on sale date.* 1 Yr

All calibrations are performed in accordance with ISO 17025 at Bios International Corporation, 10 Park Place, Butler, NJ, 07405, 800-663-4977, an ISO 17025:2005 – accredited laboratory through NVLAP. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

All units tested in accordance with Bios International Corporation test number PR17-13 using high-purity bottled nitrogen or dry filtered laboratory air.

Calibration Data

Technician Zenaida Ortiz

Lab. Pressure 755 mmHg
Lab. Temperature 22.2 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
100.88 ccm	100.375 ccm	0.5 %	1.00%	In Tolerance
1,008.2 ccm	1007 ccm	0.12 %	1.00%	In Tolerance
5,014.1 ccm	5005.6 ccm	0.17 %	1.00%	In Tolerance
22.2 °C	22.2 °C	-	±0.8°C	In Tolerance
755 mmHg	755 mmHg	-	±3.5 mHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML 500-24	113775	4/27/2010	4/27/2011
Precision Thermometer	305460	4/29/2010	4/29/2011
Precision Barometer	431/98-07	4/16/2010	4/16/2011

Calibration Notes

Bios is an ISO 17025-accredited metrology laboratory. Each Bios primary gas flow standard is dynamically verified by comparing it to one of our laboratory standards, which is a Proven DryCal® Technology volumetric piston prover of much higher accuracy but of similar operating principles. For this purpose, a flow generator of ±0.03% stability is used. Our laboratory standards are qualified by direct measurement of their dimensions (diameter, length and time) using NIST-traceable precision gauges and instruments, such as depth micrometers and laser micrometers. NIST numbers for these gauges and instruments are available upon request. Rigorous analyses of our laboratory standards' uncertainties have been performed, in accordance with The Guide to the Expression of Uncertainty in Measurement (the GUM), assuring their traceable accuracy.

Harvey Padden, President and Chief Metrologist

Gas Analyzers Calibrations

Date	3/8/2014
Project	477-S-01-1
Run #	1
Appliance/Fuel	Harman / Pellet
Personnel	LYP

start of Test: 1:56

End test: 3:55 (3:57 on other computers)

	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-500 ppm	80
NOx	0-500 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

END PSI

ZERO

			PRE-CAL		POST-CAL	
			Instrument		Instrument	
	Cylinder #	Standard Gas	Response	Time	Response	Time
VOC		0	0.66	8:42	0.1388	4:01
NO		0	0.169		0.1537	4:05
NOx		0	-0.1679		0.000	
SO2		0	0.2477		0.2447	
CO (ppm)		0	0.1879	9:00	0.1574	
CO2		0				
O2		0				
CO (%)		0				

SPAN

			Instrument		Instrument	
	Cylinder #	Standard Gas	Response	Time	Response	Time
VOC		451.7	454.7	9:19	453.9	4:13
NO		443.0	447.4			
NOx		—	—			
SO2		89.2	90.9		87.6	4:12
CO (ppm)		452.7	455.4	9:51		
CO2						
O2						
CO (%)						

LOW CHECK

			Instrument		Instrument	
	Cylinder #	Standard Gas	Response	Time	Response	Time
VOC		55.36	60.0	10:04	~~44.3~~	
NO		5.037	5.6			
NOx		5.205	5.49			
SO2		10.99	11.4			~~4:12~~
CO (ppm)		73.20	69.4	10:10	64.2	4:22
CO2						
O2						
CO (%)						

other stds Run

NO	45.18	44.1	4:10
NOx	45.40	43.9	

Gas Analyzers Calibrations

Date 3/9/11
Project 477-S-01-1
Run # 2
Appliance/Fuel Drolet/Birch/High
Personnel JC

File Name: ~~FNSB_Gas Calibration (OES Booth)_2~~ JC
FNSB_EPA Wood Stove Birch High_Gas ~~Analyzer Cal~~ JC

	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-500 ppm	80
NOx	0-500 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

Traverse

ZERO

			PRE-CAL		POST-CAL		
			Instrument		Instrument		
	Cylinder #	Standard Gas	Response	Time	Response	Time	1)
VOC	~~CC33365~~ ↑	0	0.1491	9:47	0.1491	3:53	2)
NO	000000AWC858	0	0.1537	10:00	0.1385	3:54	
NOx		0	0.0610	10:00	0.0000	3:54	3)
SO2	~~CC33365~~	0	0.0009	9:51	0.0000	3:55	c)
CO (ppm)		0	0.1879	9:54	0.1421	3:55	
CO2		0	0.00	11:45	0.07	4:22	4)
O2		0	0.00	11:45	0.00	4:22	
CO (%)	↓	0	0.00	11:45	0.00	4:22	5)

6)

SPAN

			Instrument		Instrument		
	Cylinder #	Standard Gas	Response	Time	Response	Time	5)
VOC	CC33365	451.7	451.6485	10:14	453.9072	4:04	
NO	CC280202	442.7	442.822	10:24	428.614	4:09	
NOx	CC280202	443.0	443.7609	10:26	429.664	4:09	
SO2	CC33365	89.92	89.9716	10:08	89.1670	4:00	
CO (ppm)	CC280202	452.7	453.3016	10:28	453.2406	4:08	
CO2	CC337886	16.76	16.75 ~~17.33~~	11:48	13.86	~~13.80~~ 4:27	
O2	Amb. Air	20.946	20.94	11:50	20.80	4:30	
CO (%)	CC 337886	4.327	4.33	11:48	3.550	4:27	

LOW CHECK

			Instrument		Instrument	
	Cylinder #	Standard Gas	Response	Time	Response	Time
VOC	CC261974	55.36	59.9553	10:41	59.9400	4:15
NO	CC261974	5.037	5.1896	10:36	5.6169	4:14
NOx	CC261974	5.205	5.5093	10:36	5.9977	4:14
SO2	CC261974	10.99	11.0052	10:35	11.2010	4:14
CO (ppm)	―	―	―	―	―	―
CO2	CC 75242	10.17	10.48	11:57	8.48	4:29
O2	CC 75242	10.56	10.64	11:57	12.68	4:29
CO (%)	CC 75242	2.512	2.61	11:57	2.09	4:29

Gas Analyzers Calibrations

Date	3/10/2011
Project	477-S-01-1
Run #	3
Appliance/Fuel	EPA WS / ~~Birch/Low~~ Spruce/High
Personnel	JC
Test Start Time	12:45 (actual) (12:43 gas file)
Test End Time	2:06 (gas file)
File Name	FNSB_EPA Wood Stove Spruce High_Gas

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-500 ppm	80
NOx	0-500 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

ZERO		PRE-CAL		POST-CAL	
		Instrument		Instrument	
	Standard Gas	Response	Time	Response	Time
VOC	0	0.1643	8:52	0.1338	2:17
NO	0	~~0.14~~ 0.1232	9:53	0.1232	2:38
NOx	0	0.0153	~~8~~ 9:52	0.0485	2:37
SO2	0	0.0009	9:48 AM	0.6005	2:39
CO (ppm)	0	0.0963	9:51	0.0810	2:37
CO2	0	0.00	11:15	0.06	2:50
O2	0	0.00	11:15	-0.10	2:50
CO (%)	0	0.00	11:15	-0.00	2:50
SPAN					
		Instrument		Instrument	
	Standard Gas	Response	Time	Response	Time
VOC	451.7	453.8003	8:57	450.9618	2:21
NO	442.7	442.822	10:58	442.303	2:42
NOx	443.0	444.8209	10:58	443.3406	2:42
SO2	89.92	90.0695	9:58	83.7674	2:34
CO (ppm)	452.7	452.2944	11:04	455.2552	2:44
CO2	16.76	16.76	11:20	16.86	2:51
O2	20.946	~~16.76~~ 20.95	11:20	21.09	2:53
CO (%)	4.327	4.33	11:20	4.34	2:51
LOW CHECK					
		Instrument		Instrument	
	Standard Gas	Response	Time	Response	Time
VOC	55.36	59.0244	9:46	57.9714	2:24
NO	5.037	6.1815	11:09	5.2049	2:28
NOx	5.205	6.5471	11:09	5.0820	2:28
SO2	10.99	11.3172	11:09	9.2049	2:29
CO (ppm)	—	—	—	—	—
CO2	10.17	10.11	11:24	10.18	2:52
O2	10.56	10.50	11:24	10.66	2:52
CO (%)	2.512	2.53	11:24	2.52	2:52

Tank Use	Cylinder #	Starting PSI	Ending PSI
Zero	AWC858		700
Span	CC33365/280202		1450 / 200
Low	CC261974/75242		1400 / 1600
H2/He	185695		300
Air			500

Gas Analyzers Calibrations

Date	3/17/2011
Project	477-S-01-1
Run #	5
Appliance/Fuel	EPA ws Birch Low
Personnel	JC
Background : 9:07 - 9:23 AM	
Test Start Time	11:37 AM
Test End Time	3:45 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_EPA Wood Stove Birch Low - Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1338	8:26	0.1491	3:50	1400
NO	AWC858	0	0.0000	8:30	0.0442	3:52	↓
NOx	AWC858	0	0.0000	8:30	0.0964	3:52	
SO2	AWC858	0	0.0000	8:31	0.0000	3:51	
CO (ppm)	AWC858	0	0.1268	8:30	0.1421	3:51	
CO2	AWC858	0	0.00	9:12	0.03	4:22	
O2	AWC858	0	0.00	9:12	-0.09	4:22	
CO (%)	AWC858	0	0.000	9:12	0.00	4:22	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.6324	8:39	452.6552	4:01	1300
NO	CC33365	45.18	44.9818	8:43	44.5299	3:58	1300
NOx	CC33365	45.40	45.7689	8:42	45.4132	3:58	1300
SO2	CC33365	89.92	89.9716	8:44	89.0722	3:56	1300
CO (ppm)	569161474	496.5	498.3398	8:50	500.0644	4:14	1600
CO2	CC337886	16.76	16.76	9:23	16.72	4:31	800
O2	Amb. Air	20.946	20.94	9:20	20.87	4:28	—
CO (%)	CC337886	4.327	4.33	9:23	~~0.08~~ 4.33	4:28	800

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	58.4750	8:59	57.0252	4:03	1600
NO	CC261974	5.037	5.1906	8:54	4.9417	4:06	1600
NOx	CC261974	5.205	5.4006	8:54	5.1441 ~~5.0968~~	4:09	1600
SO2	CC261974	10.99	10.9073	8:55	10.7145	4:10	1600
CO (ppm)	CC287319	20.54	19.2196	9:03	18.2123	4:16	1300
CO2	CC75242	10.17	10.11	9:25	10.10	4:33	1500
O2	CC75242	10.56	10.67	9:25	10.60	4:33	1500
CO (%)	CC75242	2.512	2.518	9:25	2.52	4:33	1500

Gas Analyzers Calibrations

Date	3/18/2011
Project	477-S-01-1
Run #	6
Appliance/Fuel	EPA Wood Stove Spruce Low
Personnel	JC/SB/AK
Background	11:25 - 11:27
Test Start Time	11:39 AM
Test End Time	3:10 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_EPA Wood Stove_Spruce Low_Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1338	9:28	0.1338	3:56 PM	
NO	AWC858	0	0.000	9:22	0.000	3:29 PM	
NOx	AWC858	0	0.000	9:22	0.041	3:29 PM	
SO2	AWC858	0	0.000	9:17	0.000	3:26 PM	
CO (ppm)	AWC858	0	0.2337	9:21	0.2489	3:29 PM	
O2	AWC858	0	0.00	10:02	0.29	4:08 PM	
CO2	AWC858	0	-0.00	10:02	0.04	4:08 PM	
CO (%)	AWC858	0	-0.00	10:02	0.002	4:08 PM	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.159	9:50	457.417	4:00 PM	
NO	CC33365	45.18	45.3284	9:45	44.26	3:43 PM	
NOx	CC33365	45.40	45.7200	9:44	44.46	3:43 PM	
SO2	CC33365	89.92	89.9747	9:43	90.268	3:36 PM	
CO (ppm)	569161474	496.5	495.4858	9:36	492.37	3:32 PM	
O2	Amb. Air	20.946	20.95	10:05	21.00	4:17 PM	
CO2	CC337886	16.76	16.75	10:03	17.01	4:17 PM	
CO (%)	CC337886	4.327	4.33	10:03	4.37	4:17 PM	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	57.5796	9:52	58.44	4:02 PM	
NO	CC261974	5.037	5.0914	9:58	5.18	3:48 PM	
NOx	CC261974	5.205	5.1396	9:59	5.25	3:48 PM	
SO2	CC261974	10.99	10.9084	9:58	11.708	3:48 PM	
CO (ppm)	CC287319	20.54	20.3337	9:39	18.303	3:52 PM	
O2	CC75242	10.56	10.70	10:07	10.58	4:16 PM	
CO2	CC75242	10.17	10.06	10:07	10.24	4:16 PM	
CO (%)	CC75242	2.512	2.50	10:07	2.63	4:16 PM	

Gas Analyzers Calibrations

Date	3/22/2011
Project	477-S-01-1
Run #	8
Appliance/Fuel	OWHH Birch High 2
Personnel	JC/SB/AK
Background	8:20 – 8:36 AM
Test Start Time	10:20 AM
Test End Time	2:24 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_EPA OWHH Birch High2_Gas

(Note: Post-cal same as Run 9)

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1491	7:38			
NO	AWC858	0	0.0000	7:32			
NOx	AWC858	0	0.0000	7:32			
SO2	AWC858	0	0.0040	7:32			
CO (ppm)	AWC858	0	0.0963	7:31			
O2	AWC858	0	0.00	8:23			
CO2	AWC858	0	-0.00	8:23			
CO (%)	AWC858	0	-0.000	8:23			

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	454.3649	7:45			
NO	CC33365	45.18	45.2719	7:52			
NOx	CC33365	45.40	45.5170	7:52			
SO2	CC33365	89.92	89.8707	7:50			
CO (ppm)	569161474	496.5	496.2942	8:03			
O2	Amb. Air	20.946	20.95	8:10			
CO2	CC337886	16.76	16.75	8:28			
CO (%)	CC337886	4.327	4.33	8:28			

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	59.0549	8:16			
NO	CC261974	5.037	5.0379	8:11			
NOx	CC261974	5.205	5.0434	8:11			
SO2	CC261974	10.99	10.8094	8:10			
CO (ppm)	CC287319	20.54	20.1506	8:06			
O2	CC75242	10.56	10.45	8:32			
CO2	CC75242	10.17	10.14	8:32			
CO (%)	CC75242	2.512	2.52	8:32			

Gas Analyzers Calibrations

Date	3/22/2011
Project	477-S-01-1
Run #	9
Appliance/Fuel	OWHH Birch Low
Personnel	AK
Background	3:10 - 3:15 PM
Test Start Time	4:56 PM
Test End Time	3:16 AM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_EPA OWHH Birch Low_Gas

(Note: Pre-cal same as Run 8)

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0			.1491	3:27	
NO	AWC858	0			.0961	3:25	
NOx	AWC858	0			.1483	3:25	
SO2	AWC858	0			.0009	3:25	
CO (ppm)	AWC858	0			.2947	3:25	
O2	AWC858	0			-0.00	3:23	
CO2	AWC858	0			0.03	3:23	
CO (%)	AWC858	0			-0.009	3:23	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7			~~500.0559~~ 466.4207	~~3:29~~ 3:3[illegible]	
NO	CC33365	45.18			34.6020	~~3:29~~ 3:3[illegible]	
NOx	CC33365	45.40			34.5393	~~3:29~~ 3:3[illegible]	
SO2	CC33365	89.92			88.1117	~~3:2~~ 3:3[illegible]	
CO (ppm)	569161474	496.5			483.4899	3:38	
O2	Amb. Air	20.946			21.01	3:38	
CO2	CC337886	16.76			16.63	3:51	
CO (%)	CC337886	4.327			4.320	3:51	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36			72.4232	3:40	
NO	CC261974	5.037			3.7433	3:43	
NOx	CC261974	5.205			3.6956	3:43	
SO2	CC261974	10.99			9.9099	3:43	
CO (ppm)	CC287319	20.54			18.3497	3:46	
O2	CC75242	10.56			10.81	3:56	
CO2	CC75242	10.17			10.02	3:56	
CO (%)	CC75242	2.512			~~2.502~~ 2.499	3:56	

Gas Analyzers Calibrations

Date	3/23/2011
Project	477-S-01-1
Run #	10
Appliance/Fuel	OWHH Spruce High
Personnel	JC
Background	10:08 - 10:14
Test Start Time	11:21 AM
Test End Time	3:18 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB-EPA OWHH Spruce High - Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1491	9:14	0.6374	3:30	900
NO	AWC858	0	0.0000	9:10	0.2365	3:28	↓
NOx	AWC858	0	0.0000	9:10	0.3879	3:28	
SO2	AWC858	0	0.0000	9:10	0.0000	3:27	
CO (ppm)	AWC858	0	0.1879	9:10	0.0000218	3:28	
O2	AWC858	0	-0.00	10:34	0.01	4:01	
CO2	AWC858	0	-0.00	10:34	-0.00	4:01	
CO (%)	AWC858	0	-0.00	10:34	-0.00	4:01	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.7545	9:21	451.6180	3:33	1000
NO	CC33365	45.18	45.2261	9:32	44.9772	3:36	↓
NOx	CC33365	45.40	45.4437	9:32	45.0744	3:36	
SO2	CC33365	89.92	90.0757	9:31	79.4630	3:40	↓
CO (ppm)	569161474	496.5	496.4932	9:39	464.5040	3:45	1000
O2	Amb. Air	20.946	20.95	10:38	21.13	3:44	—
CO2	CC337886	16.76	16.75	10:41	16.58	4:04	650
CO (%)	CC337886	4.327	4.33	10:41	4.27	4:04	650

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	61.4813	9:50	59.9400	3:54	1400
NO	CC261974	5.037	4.9952	9:46	5.0379	3:50	↓
NOx	CC261974	5.205	5.0327	9:46	5.1411	3:50	
SO2	CC261974	10.99	10.9065	9:46	9.3073	3:53	↓
CO (ppm)	CC287319	20.54	19.3112	9:41	19.3570	3:47	1150
O2	CC75242	10.56	10.76	10:43	10.73	4:05	950
CO2	CC75242	10.17	9.98	10:43	9.84	4:05	950
CO (%)	CC75242	2.512	2.50	10:43	2.46	4:05	950

Gas Analyzers Calibrations

Date	3/24/2011
Project	477-S-01-1
Run #	11
Appliance/Fuel	EPA OWHH, Spruce, Low
Personnel	JC/SB/AK
Background	9:51 - 10:05
Test Start Time	10:56 AM
Test End Time	8:38 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_EPA OWHH Spruce Low_Gas

VOC=.6679

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1491	8:50	~~.0293~~	8:45P	
NO	AWC858	0	0.0000	8:53	0.1312	8:43 P	
NOx	AWC858	0	0.0000	8:53	0.4352	8:43 P	
SO2	AWC858	0	0.0000	8:53	0.0000	8:43P	
CO (ppm)	AWC858	0	0.1421	8:53	1.1189	8:43P	
O2	AWC858	0	0.00	9:51	-0.00		
CO2	AWC858	0	0.00	9:51	-0.04		
CO (%)	AWC858	0	0.00	9:51	0.033		

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.5102	9:02	500.055	8:48	
NO	CC33365	45.18	45.3772	9:43	50.0000	8:51	
NOx	CC33365	45.40	45.5614	9:43	50.0000	8:51	
SO2	CC33365	89.92	90.0726	9:07	77.6544	8:51	
CO (ppm)	569161474	496.5	496.4327	9:11	413.1015	8:54	
O2	Amb. Air	20.946	20.95	9:54	20.94		
CO2	CC337886	16.76	16.76	9:56	16.66		
CO (%)	CC337886	4.327	4.33	9:56	4.411		

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	59.9705	9:31	67.5093	9:01	
NO	CC261974	5.037	5.3851	9:46	5.7005	9:00	
NOx	CC261974	5.205	5.3533	9:46	5.7990	9.00	
SO2	CC261974	10.99	10.9012	9:23	8.2988	9.00	
CO (ppm)	CC287319	20.54	18.2123	9:18	18.1513	8:57	
O2	CC75242	10.56	10.65	9:58	10.61		
CO2	CC75242	10.17	10.02	9:58	10.07		
CO (%)	CC75242	2.512	2.52	9:58	2.530		

Gas Analyzers Calibrations

Date	3/30/2011
Project	477-S-01-1
Run #	12
Appliance/Fuel	Conv. WS Spruce High
Personnel	AK/JC/SB
Background	12:20 - 12:22
Test Start Time	12:40
Test End Time	1:33P

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Conventional Wood Stove Spruce High_Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1643	11:36	1.5687	1:40	
NO	AWC858	0	0.0000	9:33	.0900	1:38	
NOx	AWC858	0	0.0000	9:33	.1925	1:38	
SO2	AWC858	0	0.0000	9:31	.0000	1:38	
CO (ppm)	AWC858	0	0.0000	9:31	.1879	1:38	
O2	AWC858	0	-0.00	10:37	0.13	2:02	
CO2	AWC858	0	-0.00	10:37	0.06	2:02	
CO (%)	AWC858	0	-0.00	10:37	0.000	2:02	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	451.9385	11:42	500.055	1:42	
NO	CC33365	45.18	45.1818	10:17	46.6764	1:44	
NOx	CC33365	45.40	45.4331	10:17	46.9762	1:44	
SO2	CC33365	89.92	89.9747	10:18	86.7655	1:46	
CO (ppm)	CC89280 ~~569161474~~	452.4 ~~496.5~~	452.3859	10:10	455.270	1:49	
O2	Amb. Air	20.946	20.95	10:41	20.85	1:59	
CO2	CC337886	16.76	16.75	10:43	16.64	2:04	
CO (%)	CC337886	4.327	4.33	10:43	4.234	2:04	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	57.5594	11:44	66.4108	1:57	
NO	CC261974	5.037	5.0410	10:22	6.4532	1:54	
NOx	CC261974	5.205	5.1426	10:22	6.7087	1:54	
SO2	CC261974	10.99	11.3111	10:22	10.9073	1:56	
CO (ppm)	CC287319	20.54	19.2501	10:27	21.2647	1:52	
O2	CC75242	10.56	10.68	10:45	10.57	2:06	
CO2	CC75242	10.17	10.12	10:45	10.10	2:06	
CO (%)	CC75242	2.512	2.52	10:45	2.455	2:06	

Gas Analyzers Calibrations

Date	3/31/2011
Project	477-S-01-1
Run #	13
Appliance	Conventional WS
Fuel/Burn Rate	Birch/High
Personnel	AK/JC/SB
Background	10:18 - 10:20 AM
Test Start Time	11:38 AM
Test End Time	12:18 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

Pitot tube not at center 11:38 - 11:57

File Name FNSB_Conventional Wood Stove Birch High_Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1491	9:00	0.1338	2:55	600
NO	AWC858	0	0.0000	8:53	0.0000	2:57	
NOx	AWC858	0	0.0000	8:53	0.0000	2:57	
SO2	AWC858	0	0.0000	8:53	0.0000	2:57	
CO (ppm)	AWC858	0	0.1268	8:57	1.1799	2:57	
O2	AWC858	0	-0.00	10:13	0.02	3:20	
CO2	AWC858	0	- 0.00	10:13	- 0.00	3:20	
CO (%)	AWC858	0	- 0.00	10:13	- 0.00	3:20	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.7392	9:16	462.9262	3:05	700
NO	CC33365	45.18	45.2704	10:04	44.3238	3:01	700
NOx	CC33365	45.40	45.5079	10:04	44.4592	3:02	700
SO2	CC33365	89.92	90.3742	9:12	88.5644	3:02	700
CO (ppm)	CC89280	452.4	453.2559	9:05	453.2252	3:14	1800
O2	Amb. Air	20.946	20.95	10:16	21.17	3:09	
CO2	CC337886	16.76	16.76	10:18	16.70	3:22	600
CO (%)	CC337886	4.327	4.33	10:18	4.33	3:22	600

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	60.4741	9:47	57.9561	3:07	900
NO	CC261974	5.037	5.1372	10:08	4.7845	3:09	900
NOx	CC261974	5.205	5.2510	10:08	4.7885	3:10	900
SO2	CC261974	10.99	10.9042	9:51	10.2985	3:11	900
CO (ppm)	CC287319	20.54	19.2501	9:55	20.1659	3:16	1050
O2	CC75242	10.56	10.76	10:21	10.77	3:23	750
CO2	CC75242	10.17	10.13	10:21	10.10	3:23	750
CO (%)	CC75242	2.512	2.52	10:21	2.51	3:23	750

Gas Analyzers Calibrations

Date	4/1/2011
Project	477-S-01-1
Run #	14
Appliance	Conventional WS
Fuel/Burn Rate	Spruce/Low
Personnel	AK/JC/SB
Background	~~8:~~ 9:39-9:41 AM
Test Start Time	11:17 AM
Test End Time	12:10 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Conventional Wood Stove Spruce Low_Gas

(Note: Post-cal same as Run #15)

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1491	8:46 AM			
NO	AWC858	0	0.0000	8:53			
NOx	AWC858	0	0.0000	8:53			
SO2	AWC858	0	0.5427	8:53			
CO (ppm)	AWC858	0	0.1116	8:53			
O2	AWC858	0	- 0.00	9:53			
CO2	AWC858	0	- 0.00	9:53			
CO (%)	AWC858	0	- 0.00	9:53			

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.3730	9:09			
NO	CC33365	45.18	45.1360	9:05			
NOx	CC33365	45.40	45.3628	9:05			
SO2	CC33365	89.92	90.4703	9:06			
CO (ppm)	CC89280	452.4	452.3702	8:57			
O2	Amb. Air	20.946	20.95	9:56			
CO2	CC337886	16.76	16.75	9:58			
CO (%)	CC337886	4.327	4.33	9:58			

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	56.5674	9:11			
NO	CC261974	5.037	4.9937	9:14			
NOx	CC261974	5.205	5.1899	9:14			
SO2	CC261974	10.99	10.8094	9:15			
CO (ppm)	CC287319	20.54	18.2734	8:59			
O2	CC75242	10.56	10.68	10:00			
CO2	CC75242	10.17	10.48	10:00			
CO (%)	CC75242	2.512	2.61	10:00			

NOx ILF change @ 11:50

Gas Analyzers Calibrations

Date	4/1/2011
Project	477-S-01-1
Run #	15
Appliance	Conventional WS
Fuel/Burn Rate	Birch/Low
Personnel	AK/JC/SB
Background	1:30 - 1:32 PM
Test Start Time	3:07 PM
Test End Time	3:56 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Conventional Wood Stove Birch Low_Gas

(Note: Pre-cal same as Run # 14)

ZERO

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	AWC858	0			1.5488	4:24	
NO	AWC858	0			.0320	4:21	
NOx	AWC858	0			.1330	4:21	
SO2	AWC858	0			.0600	4:21	
CO (ppm)	AWC858	0			1.2715	4:21	
O2	AWC858	0			.10	4:42	
CO2	AWC858	0			.01	4:42	
CO (%)	AWC858	0			.004	4:42	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7			467.9469	4:25	
NO	CC33365	45.18			43.0552	4:28	
NOx	CC33365	45.40			44.1692	4:28	
SO2	CC33365	89.92			64.5357	4:28	
CO (ppm)	CC89280	452.4			364.98	4:29	
O2	Amb. Air	20.946			20.94	4:20	
CO2	CC337886	16.76			16.85	4:42	
CO (%)	CC337886	4.327			4.721	4:42	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36			60.9283	4:30	
NO	CC261974	5.037			6.1936	4:32	
NOx	CC261974	5.205			6.4411	4:34	
SO2	CC261974	10.99			9.2062	4:34	
CO (ppm)	CC287319	20.54			19.2807	4:32	
O2	CC75242	10.56			10.37	4:51	
CO2	CC75242	10.17			10.22	4:51	
CO (%)	CC75242	2.512			2.641	4:51	

Gas Analyzers Calibrations

Date	4/12/2011
Project	477-S-01-1
Run #	17
Appliance	Oil Burner
Fuel/Burn Rate	No. 2 Fuel Oil
Personnel	AK/JC/SB
Background	
Test Start Time	7:05:50
Test End Time	~~4/~~ 10:40:00

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name ENSB — No 2 Fuel oil — 17

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1421	9:35	.1185	8:36	
NO	AWC858	0	0.0000	9:40	.1281	835	
NOx	AWC858	0	0.0000	9:40	.1834	8:35	
SO2	AWC858	0	0.0004	9:40	.5944	8:35	
CO (ppm)	AWC858	0	0.0463	9:40	.1726	8:35	
O2	AWC858	0	0.00	11:14	-.11	8:41	
CO2	AWC858	0	0.00	11:19	0.11	8:41	
CO (%)	AWC858	0	0.000	11:14	0.000	8:41	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC33365	451.7	453.708	10:44	N/A	N/A	8
NO	CC33365	45.18	45.13	10:38			0
NOx	CC33365	45.40	47.0297	10:38			0
SO2	CC~~33365~~ 5	~~89.92~~ 88.47	89.6626	10:56	86.9582	8:44	
CO (ppm)	CC89280	452.4	452.37	10:56	454.4005	8:44	
O2	Amb. Air	20.946	20.94	11:28	20.91	8:36	
CO2	CC337886	16.76	16.76	11:19	16.86	9:00	
CO (%)	CC337886	4.327	4.327	11:19	4.342	9:00	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	60.9777	11:04	59.9400	8:50	
NO	CC261974	5.037	6.908	11:03	8.4813	8:49	
NOx	CC261974	5.205	7.5070	11:03	9.5417	8:49	
SO2	CC261974	10.99	9.5061	11:03	11.9015	8:49	
CO (ppm)	CC287319	20.54	15.3431	11:09	16.3198	8:53	
O2	CC75242	10.56	10.71	11:20	10.67	9:01	
CO2	CC75242	10.17	10.22	11:20	10.14	9:01	
CO (%)	CC75242	2.512	2.534	11:20	2.509	9:01	

Gas Analyzers Calibrations

Date	4/15/2011
Project	477-S-01-1
Run #	~~AK17~~ 18
Appliance	Waste Oil
Fuel/Burn Rate	Waste Oil
Personnel	AK/JC/SB
Background	9:05 Am
Test Start Time	9:15 AM
Test End Time	11:58 Am

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-50 ppm	80
NOx	0-50 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB – Waste oil – 18

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWC858	0	0.1378	8:18	.1491	12:09	500
NO	AWC858	0	0.0000	8:14	.4884	12:06	
NOx	AWC858	0	0.0000	8:14	.4887	12:06	
SO2	AWC858	0	0.0000	8:19	.4934	12:06	
CO (ppm)	AWC858	0	.0963	8:14	6.1341	12:06	
O2	AWC858	0	0.00	8:24	-.04	12:13	
CO2	AWC858	0	0.00	8:24	.01	12:13	
CO (%)	AWC858	0	0.000	8:24	-.002	12:13	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI	
VOC	CC276183	225.4	225.77	8:34			1850	234.92 @ 12:2[illegible]
NO	CC276183	22.20	22.3809	~~[illegible]~~ 8:40	~~.4444~~ AK	~~.4687~~ 12:06	1850	26.9346 @ 12:2[illegible]
NOx	CC276183	22.27	22.6884	8:40	~~.4887~~	~~12:06~~ AK	1850	27.3420 @ 12:2[illegible]
SO2	CC89280	88.92	84.6718	8:46	~~.4934~~	~~12:06~~	1600	76.4618 @ 12:22
CO (ppm)	CC89280	452.4	453.37	8:46			1600	382.1800 @ 12:22
O2	Amb. Air	20.946	20.94	8:20	20.74	12:13		
CO2	CC337886	16.76	16.76	8:26	16.65	12:15	600	
CO (%)	CC337886	4.327	4.327	8:26	4.300	12:15	600	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	57.0405	8:55	58.4547	12:32	500
NO	CC261974	5.037	7.7539	8:52	4.3466	12:31	500
NOx	CC261974	5.205	8.5037	8:52	11.0858	12:31	500
SO2	CC261974	10.99	9.2981	8:52	10.2006	12:31	500
CO (ppm)	CC287319	20.54	15.1599	8:59	14.1586	12:34	600
O2	CC75242	10.56	10.63	8:28	10.57	12:17	700
CO2	CC75242	10.17	10.12	8:28	10.08	12:17	700
CO (%)	CC75242	2.512	2.518	8:28	2.499	12:17	700

Gas Analyzers Calibrations

Date	5/6/2011
Project	477-S-01-1
Run #	20
Appliance	Coal Stove
Fuel/Burn Rate	Dry Stoker / High
Personnel	AK/JC/SB
Background	10:42 – 10:45
Test Start Time	11:25 AM
Test End Time	2:59 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_ Coal Stove Dry Coal High _ Gas

ZERO

			PRE-CAL		POST-CAL		
			Instrument		Instrument		
	Cylinder #	Standard Gas	Response	Time	Response	Time	End PSI
VOC	AWC858	0	0.1185	9:27	0.1491	3:06	2200
NO	AWC858	0	0.0185	9:43	0.1315	3:05	↓
NOx	AWC858	0	0.0031	9:43	0.2198	3:05	
SO2	AWC858	0	0.0000	9:42	0.1906	3:05	
CO (ppm)	AWC858	0	0.0810	9:42	0.0810	3:04	
O2	AWC858	0	0.01	10:23	0.08	3:35	
CO2	AWC858	0	0.00	10:23	-0.00	3:35	
CO (%)	AWC858	0	-0.00	10:23	-0.00	3:35	

AWB483

1) 10:13
2) 10:15
3) 10:17
5) 10:18
4) 10:21
5) 10:22
6) 10:23
5) 10:19

SPAN

			Instrument		Instrument		
	Cylinder #	Standard Gas	Response	Time	Response	Time	End PSI
VOC	CC89280	454.2	454.2123	9:59	456.9897	3:10	1400
NO	CC5643	91.08	91.3540	9:50	92.7671	3:18	1750
NOx	CC5643	91.40	91.4387	9:50	93.4479	3:18	1750
SO2	CC89280	88.92	88.9682	9:55	87.3651	3:14	1400
CO (ppm)	CC89280	452.4	452.1723	9:55	448.1432	3:14	1400
O2	Amb. Air	20.946	20.95	10:26	21.01	3:32	
CO2	CC337886	16.76	16.77	10:28	16.68	3:37	400
CO (%)	CC337886	4.327	4.33	10:28	4.32	3:37	400

LOW CHECK

			Instrument		Instrument		
	Cylinder #	Standard Gas	Response	Time	Response	Time	End PSI
VOC	CC261974	55.36	57.5136	10:05	59.5127	3:27	650
NO	CC261974	5.037	4.7034	10:08	5.0208	3:25	650
NOx	CC261974	5.205	4.9111	10:08	5.1980	3:25	650
SO2	CC261974	10.99	10.7023	10:09	10.9073	3:25	650
CO (ppm)	CC287319	20.54	18.1818	10:11	18.1971	3:20	650
O2	CC75242	10.56	10.66	10:30	10.70	3:39	550
CO2	CC75242	10.17	10.12	10:30	10.06	3:39	550
CO (%)	CC75242	2.512	2.51	10:30	2.51	3:39	550

Pbar = 30.14 in Hg

Gas Analyzers Calibrations

Date	5/9/2011
Project	477-S-01-1
Run #	21
Appliance	Coal Stove
Fuel/Burn Rate	Drystoker / Low
Personnel	AK/JC/SB
Background	10:33-10:36 AM
Test Start Time	12:15 PM
Test End Time	6:42 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB - ~~Dry~~ Coal Stove Dry Stoker Coal Low - Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1185	9:53	.1185	~~6:50~~ 6:51	
NO	AWB483	0	0.0246	9:48	.0155	6:50	
NOx	AWB483	0	0.0122	9:48	.1099	6:50	
SO2	AWB483	0	0.0000	9:48	0.0000	6:50	
CO (ppm)	AWB483	0	0.0963	9:48	.0963	6:50	
O2	AWB483	0	-0.00	10:42	.02	6:53	
CO2	AWB483	0	-0.00	10:42	.02	6:53	
CO (%)	AWB483	0	-0.00	10:42	.000	6:53	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	456.9282	10:01	477.5304	6:55	
NO	CC5643	91.08	91.0763	10:14	78.1295	7:02	
NOx	CC5643	91.40	91.4579	10:14	78.8124	7:02	
SO2	CC89280	88.92	88.8948	10:06	73.7543	6:59	
CO (ppm)	CC89280	452.4	452.2486	10:07	399.0916	6:59	
O2	Amb. Air	20.946	20.95	10:46	20.93	6:52	
CO2	CC337886	16.76	16.76	10:47	16.77	7:12	
CO (%)	CC337886	4.327	4.33	10:47	4.320	7:12	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	59.5280	10:26	59.5286	7:06	
NO	CC261974	5.037	4.6241	10:23	4.6949	7:05	
NOx	CC261974	5.205	4.8045	10:23	5.0088	7:05	
SO2	CC261974	10.99	11.0021	10:23	10.2006	7:05	
CO (ppm)	CC287319	20.54	18.1971	10:17	14.1629	~~7:05~~ 7:10	
O2	CC75242	10.56	10.64	10:49	16.71	7:13	
CO2	CC75242	10.17	10.11	10:49	10.15	7:13	
CO (%)	CC75242	2.512	2.51	10:49	2.510	7:13	

Traverse
1) 4:08
2) 4:10
3) 4:12
c) ~~4:13~~ 4:13
4) ~~4:15~~ 4:14
5) 4:15
6) 4:18
8) 4:20

Gas Analyzers Calibrations

Date	5/11/2011
Project	477-S-01-1
Run #	23
Appliance	Coal Stove
Fuel/Burn Rate	Wet coal/Low
Personnel	AK/JC/SB
Background	10:50-10:52 AM
Test Start Time	~~10:58~~ 10:57:30
Test End Time	4:02 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Coal Stove Wet Stoker Coal Low 2_Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1491	9:28	0.1338	4:07	1950
NO	AWB483	0	0.0216	8:00	0.0124	4:09	↓
NOx	AWB483	0	0.0031	8:00	0.1068	4:09	
SO2	AWB483	0	0.0000	8:00	0.0000	4:09	
CO (ppm)	AWB483	0	0.0810	8:00	0.0963	4:09	
O2	AWB483	0	-0.00	8:46	-0.00	4:41	
CO2	AWB483	0	-0.00	8:46	0.03	4:41	
CO (%)	AWB483	0	-0.00	8:46	0.00	4:41	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	454.8380	9:16	462.3462	4:20	1050
NO	CC5643	91.08	91.1587	8:08	76.9331	4:25	1650
NOx	CC5643	91.40	91.5494	8:08	76.6178	4:25	1650
SO2	CC89280	88.92	88.9743	8:15	73.3383	4:13	1050
CO (ppm)	CC89280	452.4	453.3780	8:19	439.2380	4:12	1050
O2	Amb. Air	20.946	20.95	8:49	21.08	4:45	
CO2	CC337886	16.76	16.75	9:00	16.87	4:42	400
CO (%)	CC337886	4.327	4.33	9:00	4.33	4:42	400

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	55.5907	9:20	60.4589	4:33	650
NO	CC261974	5.037	4.2182	8:27	4.2151	4:28	↓
NOx	CC261974	5.205	4.2854	8:27	4.8989	4:28	
SO2	CC261974	10.99	8.8055	8:28	10.4056	4:27	↓
CO (ppm)	CC287319	20.54	20.2116	8:21	19.1586	4:27	500
O2	CC75242	10.56	~~[illegible]~~ 10.86	~~9:03~~ 9:53	10.87	4:44	400
CO2	CC75242	10.17	~~9.66~~ 10.06	~~9:03~~ 9:53	10.14	4:44	↓
CO (%)	CC75242	2.512	~~2.44~~ 2.50	~~9:03~~ 9:53	2.51	4:44	↓

Pbar @ 10:59 = 29.94 in Hg
Note: missed pt @ 11:04 AM, CO

Nox filter change 11:24 - 11:25

VOC filter change 12:00 PM

Note: Tunnel CO (ppm) out of operation

Gas Analyzers Calibrations

Date	5/27/2011
Project	477-S-01-1
Run #	25
Appliance	Non-Q OWHH
Fuel/Burn Rate	~~Birch / High~~ Spruce
Personnel	AK/JC/SB
Background	10:22
Test Start Time	10:22
Test End Time	

Pbar = 30.02 in Hg

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name: FNSB – Non Q OWHH Spruce High – Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1796	7:50	4.4733	12:53	1700
NO	AWB483	0	0.0307	7:54	.1437	12:56	
NOx	AWB483	0	0.0122	7:54	.2350	12:56	
SO2	AWB483	0	0.0988	7:55	.6080	12:56	
CO (ppm)	AWB483	0	0.1421	7:59	5.1438	12:56	
O2	AWB483	0	0.00	8:52	-.07	12:58	
CO2	AWB483	0	0.00	8:52	.04	12:58	
CO (%)	AWB483	0	0.000	8:52	.009	12:56	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	454.7769	10:05	443.248	1:10	850
NO	CC5643	91.08	91.2533	10:14	86.8400	1:16	1400
NOx	CC5643	91.40	91.5891	10:14	88.0684	1:16	1400
SO2	CC89280	88.92	88.9774	10:01	88.2676	1:14	850
CO (ppm)	CC89280	452.4	—	—	—	—	— JC
O2	Amb. Air	20.946	20.95	8:54	20.84	1:02	
CO2	CC337886	16.76	16.76	8:58	16.82	1:05	150
CO (%)	CC337886	4.327	4.327	8:58	4.344	1:05	150

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280 ~~CC261974~~	½ ~~55.36~~ 454.2	227.0586	10:07	219.6365	1:28	850
NO	CC261974	5.037	5.1155	10:18	5.6160	1:20	400
NOx	CC261974	5.205	5.2041	10:18	6.7160	1:20	400
SO2	CC261974	10.99	10.9073	10:17	13.0212	1:20	400
CO (ppm)	CC287319	20.54	—	—	—	—	— JC
O2	CC75242	10.56	10.62	8:59	10.60	1:07	350
CO2	CC75242	10.17	10.10	8:59	10.18	1:07	350
CO (%)	CC75242	2.512	2.513	8:59	2.531	1:07	350

Note: @10:22, 50% dilution for VOC
@10:29, 80% dilution
@10:30, 8.0/9.5 dilution
@10:51, 5.0/9.5
@ 11:10 ~~7~~, 0/9.5

Stack Gas Sample : 2/2.6

Filter Changes CO/NOx/SO2 @10:26 @10:38

Gas Analyzers Calibrations

Date	5/30/2011
Project	477-S-01-1
Run #	26
Appliance	NAOW114
Fuel/Burn Rate	Coal
Personnel	AK/JC/SB
Background	~~10:36~~ 10:37-10:52
Test Start Time	11:35
Test End Time	13:38

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

11:43 - VOC Dilution

11:58 - Changed non-VOC filter

File Name

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	.1796	9:25	6.0244	14:15	
NO	AWB483	0	.0277	9:31	.0216	14:13	
NOx	AWB483	0	.0122	9:31	.8119	14:13	
SO2	AWB483	0	.0000	9:32	.2927	14:13	
CO (ppm)	AWB483	0	N/A				
O2	AWB483	0	0.00	8:49	0.09	13:59	
CO2	AWB483	0	0.00	8:49	0.00	13:59	
CO (%)	AWB483	0	0.000	8:49	-0.015	13:59	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	454.7000	10:17	464.3160	14:17	
NO	CC5643	91.08	91.6836	10:11	88.7532	14:30	
NOx	CC5643	91.40	91.9768	10:11	94.9552	14:30	
SO2	CC89280	88.92	88.9774	10:25	75.4625	14:28	
CO (ppm)	CC89280	452.4	N/A				
O2	Amb. Air	20.946	20.95	8:52	20.88	14:03	
CO2	CC337886	16.76	16.76	8:55	16.73	14:01	~50
CO (%)	CC337886	4.327	4.327	8:55	4.299	14:01	~50

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	1/2 CC89280	227.1	227.546	10:31	243.2438	14:19	
NO	CC261974	5.037	4.5936	10:35	5.8291	14:33	
NOx	CC261974	5.205	4.6150	10:35	7.0080	14:33	
SO2	CC261974	10.99	9.9161	10:35	11.2101	14:33	
CO (ppm)	CC287319	20.54	N/A				
O2	CC75242	10.56	10.64	8:56	10.67	14:05	400
CO2	CC75242	10.17	10.10	8:56	10.03	14:05	400
CO (%)	CC75242	2.512	2.514	8:56	2.477	14:05	400

@ 20 min

Turned off stack gas Dilution

Gas Analyzers Calibrations

Date	6/1/2011
Project	477-5-01-1
Run #	7th 27
Appliance	NonQ OWHH (w/ Catalyst)
Fuel/Burn Rate	Coal/Low
Personnel	AK/JC/SB
Background	10:18-10:20
Test Start Time	11:45 AM
Test End Time	15:00 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name ENSB Supplemental - NonQ OWHH (w/ Catalyst) Coal Low - Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1643	8:27	6.0244	3:09	1400
NO	AWB483	0	0.0277	8:33	0.1284	3:14	↓
NOx	AWB483	0	0.0092	8:33	3.0980	3:14	
SO2	AWB483	0	0.1049	9:33	0.0957	3:13	
CO (ppm)	AWB483	0	0.3252	9:36	-0.3158	3:13	
O2	AWB483	0	0.00	9:02	0.03	3:45	
CO2	AWB483	0	0.00	9:02	0.01	3:45	
CO (%)	AWB483	0	0.000	9:02	-0.00	3:45	✓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	455.2958	9:49	~~482.~~ 480.3232	3:24	500
NO	CC5643	91.08	91.1617	10:08	97.0461	3:31	
NOx	CC5643	91.40	91.7448	10:08	97.2389	3:31	
SO2	CC89280	88.92	88.6806	10:01	87.4691	3:21	500
CO (ppm)	CC89280	452.4	453.6832	10:00	481.4753	3:16	500
O2	Amb. Air	20.946	20.95	9:05	20.98	3:45	
CO2	CC337886	16.76	16.76	9:08	16.81	3:47	400
CO (%)	CC337886	4.327	4.327	9:08	4.29	3:47	<100

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC261974	55.36	56.0486	9:52	65.4949	3:28	500
NO	CC261974	5.037	6.0189	10:13	4.7034	3:37	500
NOx	CC261974	5.205	6.1076	10:13	5.2997	3:37	500
SO2	CC261974	10.99	10.8063	10:13	9.2063	3:39	500
CO (ppm)	CC287319	20.54	19.7385	10:10	19.7233	3:35	500
O2	CC75242	10.56	10.64	1:09	10.67	3:50	400
CO2	CC75242	10.17	10.08	9:09	~~10.39~~ 10.06	3:~~48~~ 50	400
CO (%)	CC75242	2.512	2.511	9:09	~~2.67~~ 2.51	3:~~48~~ 50	400

Filter Changes
VOC = 11:53
NOx = 11:50
11:56 - 12:00
1:33

Note: VOC over range 11:47 - 12:02
CO over 11:47 - 12:08
CO & SO_2 disengaged 1:39 - 1:41 PM

Gas Analyzers Calibrations

Date	6/7/2011
Project	477-S-01-1
Run #	28
Appliance	Auger-fed OWHH
Fuel/Start	Coal/Cold
Personnel	AK/JC/SB
Background	8:50-8:52 AM
Test Start Time	9:29:40 AM (Sampling) 9:30:30 (auger)
Test End Time	12:49 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	80
NOx	0-100 ppm	80
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name: FNSB Supplemental - Auger coal OWHH Cold Start - Gas

ZERO

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	AWB483	0	0.1491	8:05			
NO	AWB483	0	0.0000	7:28			
NOx	AWB483	0	0.0000	7:28			
SO2	AWB483	0	0.1110	7:30			
CO (ppm)	AWB483	0	0.0658	7:30			
O2	AWB483	0	0.00	8:38			
CO2	AWB483	0	0.00	8:38			
CO (%)	AWB483	0	0.00	8:38			

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2	455.7078	8:09			
NO	CC5643	91.08	91.1275	7:35			
NOx	CC5643	91.40	91.4201	7:35			
SO2	CC89280	88.92	89.8866	7:40			
CO (ppm)	CC89280	452.4	453.1338	7:44			
O2	Amb. Air	20.946	20.95	8:48			
CO2	CC53847	19.99	19.98	8:41			
CO (%)	CC53847	4.501	4.50	8:41			

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	1/2 CC89280	227.1	212.5485	8:12			
NO	CC287319	4.987	5.0991	7:47			
NOx	CC287319	5.022	5.2009	7:47			
SO2	CC261974	10.99	9.7142	7:56			
CO (ppm)	CC287319	20.54	19.1891	7:47			
O2	CC287205	10.00	10.35	8:52			
CO2	CC287205	10.07	10.02	8:52			
CO (%)	CC287205	2.266	2.26	8:52			

Pbar = 30.13 in Hg

Run 28 Post-Cal = Run 29 Post-Cal

Gas Analyzers Calibrations

Date	6/7/2011
Project	477-S-01-1
Run #	29
Appliance	Auger-fed OWHH
Fuel/Start	Coal/Hot
Personnel	AK/JC/SB
Background	1:46 – 1:48 PM
Test Start Time	1:51 PM
Test End Time	5:13 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509 ~~80~~ JC
NOx	0-100 ppm	509 ~~80~~ JC
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB Supplemental_Auger coal OWHH Hot Start_Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0			0.1643	5:17	1150
NO	AWB483	0			0.0999	5:19	↓
NOx	AWB483	0			0.0977	5:19	
SO2	AWB483	0			0.0087	5:20	
CO (ppm)	AWB483	0			0.0505	5:19	
O2	AWB483	0			0.04	5:43	
CO2	AWB483	0			0.07	5:43	
CO (%)	AWB483	0			-0.00	5:43	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC89280	454.2			457.2949	5:27	250
NO	CC5643	91.08			88.1241	5:33	1200
NOx	CC5643	91.40			87.8225	5:33	1200
SO2	CC89280	88.92			88.9927	5:23	250
CO (ppm)	CC89280	452.4			468.1363	5:23	250
O2	Amb. Air	20.946			20.84	5:45	
CO2	CC53847	19.99			19.97	5:48	1550
CO (%)	CC53847	4.501			~~-0.00~~ 4.49 JC	5:48	1550

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	1/2 CC89280	227.1			214.4382	5:29	250
NO	CC287319	4.987			5.0991	5:36	500
NOx	CC287319	5.022			5.2039	5:36	500
SO2	CC261974	10.99			10.3230	5:39	<200
CO (ppm)	CC287319	20.54			20.1048	5:35	500
O2	CC287205	10.00			10.12	5:50	2100
CO2	CC287205	10.07			10.03	5:50	2100
CO (%)	CC287205	2.266			2.25	5:50	2100

Pbar = 30.15 in Hg

JC Run 29 Pre-Cal = Run 28 Pre-Cal

Gas Analyzers Calibrations

Date	6/30/2011
Project	477-S-01-1
Run #	30
Appliance	Non Q OWHH
Fuel/Start	Spruce/Low/Hot start
Personnel	AK/JC/SB
Background	11:50-11:54
Test Start Time	2:18 PM
Test End Time	4:20 PM

Pbar = 30.22 in Hg

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name

ZERO

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	AWB483	0	0.1491	8:53	0.1491	4:33	1000
NO	AWB483	0	0.0006	9:41	0.3991	4:25	
NOx	AWB483	0	0.0019	9:41	0.6926	4:25	
SO2	AWB483	0	0.3099	9:41	0.5118	4:25	
CO (ppm)	AWB483	0	0.1726	9:41	1.0883	4:28	
O2	AWB483	0	0.00	11:25	0.25	4:57	
CO2	AWB483	0	0.00	11:25	0.09	4:57	
CO (%)	AWB483	0	0.00	11:25	0.02	4:57	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	468.4652	9:10	467.2448	4:37	1400
NO	CC5643	91.08	91.2044	9:58	95.0115	4:47	1150
NOx	CC5643	91.40	91.7050	9:58	94.9026	4:47	1150
SO2	CC108971	89.8	89.8860	9:51	88.0841	4:41	1400
CO (ppm)	SG9161474	496.5	497.3020	10:02	491.1056	4:44	1000
O2	Amb. Air	20.95%	20.95	11:34	21.00	4:53	
CO2	ALM068058	17.10%	17.13	11:59	16.58	5:00	900
CO (%)	ALM068058	4.28%	4.28	11:34	4.15	5:00	900

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	1/2 CC108971	232.95	230.5380	9:33	—		
NO	CC287319	4.987	4.5027	11:00	5.3053	4:49	400
NOx	CC287319	5.022	4.5032	11:00	5.4063	4:49	400
SO2	CC277801	21.81	21.2324	11:10	21.9299	4:53	1900
CO (ppm)	CC287319	20.54	16.1977	11:00	21.0968	4:49	400
O2	ALM066210	5.03%	5.10	11:37	5.44	5:05	1250
CO2	ALM066210	5.06%	5.02	11:37	4.97	5:05	1250
CO (%)	ALM066210	2.50%	2.48	11:37	2.44	5:05	1250

JC (Dilution apparatus broken)

NOx Filter Changes:
2:22 - 2:25
2:26
2:30
2:36
3:25
4:01

VOC Filter Changes:
3:10 - 3:11

Pbar = 30.24 in Hg

Gas Analyzers Calibrations

Date	7/1/2011
Project	477-S-01-1
Run #	31
Appliance	Non Q OWHH
Fuel/Burn Rate	Birch / High
Personnel	AK/JC/SB
Background	9:32 –
Test Start Time	10:36
Test End Time	12:32
File Name	

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1643	8:43	0.1643	1:20	850
NO	AWB483	0	0.0000	8:38	0.6956	12:49	↓
NOx	AWB483	0	0.0000	8:38	1.0043	12:49	
SO2	AWB483	0	0.3160	8:38	0.4904	12:48	
CO (ppm)	AWB483	0	0.0963	8:39	0.0353	12:48	
O2	AWB483	0	0.00	9:23	0.30	1:30	
CO2	AWB483	0	0.00	9:23	0.05	1:30	
CO (%)	AWB483	0	0.00	9:23	0.00	1:30	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	467.9623	8:50	467.4279	1:24	1400
NO	CC5643	91.08	91.1037	8:58	89.7668	12:52	1100
NOx	CC5643	91.40	91.4005	8:58	89.8050	12:52	1100
SO2	CC108971	89.8	90.1888	8:54	86.0802	1:08	1400
CO (ppm)	SG9161474	496.5	496.4626	9:04	485.0924	12:55	1000
O2	Amb. Air	20.95%	20.94	9:25	20.85	1:23	
CO2	ALM068058	17.10%	17.10	9:28	17.91	1:34	900
CO (%)	ALM068058	4.28%	4.28	9:28	4.49	1:34	900

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	119.4105	9:14	116.4953	1:26	1850
NO	CC287319	4.987	4.8048	9:07	5.0001	1:13	350
NOx	CC287319	5.022	4.8998	9:07	5.2018	1:13	350
SO2	CC277801	21.81	21.2355	9:11	22.5326	1:11	1900
CO (ppm)	CC287319	20.54	19.2654	9:07	17.1287	1:13	350
O2	ALM066210	5.03%	5.23	9:30	4.77	1:36	800
CO2	ALM066210	5.06%	5.05	9:30	5.21	1:36	800
CO (%)	ALM066210	2.50%	2.50	9:30	2.57	1:36	800

NOx filter change
10:42

Gas Analyzers Calibrations

Date	7/6/2011
Project	477-S-01-1
Run #	32
Appliance	Non Q OWHH
Fuel/Burn Rate	Birch / Low
Personnel	AK/JC/SB
Background	10:05 – 10:07
Test Start Time	12:26
Test End Time	16:17

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB – Non Q OWHH Birch Low – Gas

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1491	8:50	13.3647	16:57	
NO	AWB483	0	0.0017	8:55	.2034	16:55	
NOx	AWB483	0	0.0171	8:55	.3147	16:55	
SO2	AWB483	0	0.0000	8:55	.8912	16:59	
CO (ppm)	AWB483	0	0.0505	8:55	.0047	16:53	
O2	AWB483	0	0.00	9:57	-.02	16:22	
CO2	AWB483	0	0.00	9:57	.20	16:22	
CO (%)	AWB483	0	0.00	9:57	.033	16:22	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	467.9468	9:36	406.1419	16:41	
NO	CC5643	91.08	91.1129	9:02	80.2143	16:50	
NOx	CC5643	91.40	91.4219	9:02	79.5306	16:50	
SO2	CC108971	89.8	89.8768	9:31	80.1635	16:46	
CO (ppm)	SG9161474	496.5	494.0970	9:25	448.81	16:53	
O2	Amb. Air	20.95%	20.94	10:03	20.80	16:21	
CO2	ALM068058	17.10%	17.09	10:01	17.11	16:26	
CO (%)	ALM068058	4.28%	4.28	10:01	4.285	16:26	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	114.9849	9:38	112.421	17:00	
NO	CC287319	4.987	5.0062	9:50	3.2121	17:07	
NOx	CC287319	5.022	5.1255	9:56	3.2244	17:07	
SO2	CC277801	21.81	21.5200	9:42	16.9066	17:05	
CO (ppm)	CC287319	20.54	20.0438	9:44	12.8611	17:08	
O2	ALM066210	5.03%	5.06	10:05	5.01	16:24	
CO2	ALM066210	5.06%	4.99	10:05	5.08	16:24	
CO (%)	ALM066210	2.50%	2.47	10:05	2.481	16:24	

NOx Filter Changes:
12:31 - 12:32
12:36
12:48
2:18 - 2:20

VOC
12:34

Gas Analyzers Calibrations

Date	~~7/7/2011~~ 7/8/2011
Project	477-S-01-1
Run #	33
Appliance	NonQ OWHH
Fuel/Burn Rate	Birch/Low/Cold
Personnel	AK/JC/SB
Background	8:09 – 8:11
Test Start Time	8:36 AM
Test End Time	2:22 PM

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name

NOx Filter: 9:18 - 9:19; 10:36 - 10:37; 10:53; 11:05; 11:12 - 11:14; 11:40; 12:22; 1:37; 2:16

VOC: 11:06 - 11:07; 2:15

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1491	7:12	1.0800	3:02	600
NO	AWB483	0	0.0017	7:06	0.1025	2:32	↓
NOx	AWB483	0	0.0171	7:06	0.3228	2:32	
SO2	AWB483	0	0.0000	7:06	1.2001	2:32	
CO (ppm)	AWB483	0	0.1726	7:08	0.0658	2:32	
O2	AWB483	0	0.00	8:05	0.00	3:13	
CO2	AWB483	0	0.00	8:05	0.12	3:13	
CO (%)	AWB483	0	0.00	8:05	0.01	3:13	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	468.1299	7:17	473.9595	3:07	1100
NO	CC5643	91.08	91.1098	7:34	89.7127	2:36	800
NOx	CC5643	91.40	91.3212	7:34	89.8325	2:36	800
SO2	CC108971	89.8	90.2776	7:24	84.5689	2:45	1100
CO (ppm)	SG9161474	496.5	496.7678	7:42	495.1653	2:40	700
O2	Amb. Air	20.95%	20.94	8:06	20.82	3:15	
CO2	ALM068058	17.10%	17.09	8:08	17.08	3:17	900
CO (%)	ALM068058	4.28%	4.28	8:08	4.27	3:17	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	118.0523	7:57	121.8674	3:08	1700
NO	CC287319	4.987	4.9085	7:45	4.9116	2:48	700
NOx	CC287319	5.022	5.0248	7:45	5.0248	2:48	700
SO2	CC277801	21.81	21.8166	7:49	21.8167	2:56	1700
CO (ppm)	CC287319	20.54	19.5248	7:45	21.1274	2:48	700
O2	ALM066210	5.03%	5.07	8:10	5.06	3:18	1250
CO2	ALM066210	5.06%	5.04	8:10	5.07	3:18	↓
CO (%)	ALM066210	2.50%	2.47	8:10	2.47	3:18	

Gas Analyzers Calibrations

Pbar = 30.21 in Hg

Date	7/27/2011
Project	477-S-01-1
Run #	34
Appliance	EPA OWHH w/ Catalyst
Fuel/Burn Rate	Birch Low
Personnel	AK/JC/SB
Background	9:00-9:02, 11:54-11:56
Test Start Time	13:26
Test End Time	22:20

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419
CO2 (tunnel)	0-25 %	220

File Name FNSB_EPA OWHH ClearStak_Gas.xlsx; FNSB_EPA OWHH w/ Catalyst - Gas

NOx Filter: 13:44 15:26

ZERO

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	AWB483	0	0.1338	8:35	0.1491	10:24	500
NO	AWB483	0	0.0000	7:49	0.2065	10:25	↓
NOx	AWB483	0	0.0202	7:49	0.2250	10:25	
SO2	AWB483	0	0.0000	7:49	0.0000	10:25	
CO (ppm)	AWB483	0	0.0658	7:50	0.0200	10:24	
CO2 (tunnel)	AWB483	0	0.0534	11:41	0.0992	10:25	
O2	AWB483	0	0.00	8:51	0.00	10:59	
CO2 (stack)	AWB483	0	0.00	8:51	0.00	10:59	
CO (%)	AWB483	0	0.00	8:51	0.00	10:59	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	467.7942	8:40	469.7476	10:43	900
NO	CC5643	91.08	91.1129	7:56	88.2118	10:27	✱
NOx	CC5643	91.40	91.4280	7:56	87.6208	10:27	
SO2	CC108971	89.8	89.8829	8:04	88.2707	10:41	900
CO (ppm)	SG9161474	496.5	497.1494	8:13	500.0064	10:37	1500
CO2 (tunnel)	CC53847	19.99%	19.9851	11:47	19.0084	10:33	2000
O2	Amb. Air	20.95%	20.94	8:53	20.92	11:05	
CO2 (stack)	ALM068058	17.10%	17.10	8:55	17.02	11:02	850
CO (%)	ALM068058	4.28%	4.28	8:55	4.26	11:02	850

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	115.5190	8:42	115.9616	10:44	1400
NO	CC287319	4.987	4.8109	8:19	~~3.6~~ 4.6126	10:52	300
NOx	CC287319	5.022	4.9272	8:19	4.7259	10:52	300
SO2	CC277801	21.81	21.1161	8:25	20.5135	10:49	1400
CO (ppm)	CC287319	20.54	19.2807	8:17	18.1360	10:52	300
CO2 (tunnel)	ALM066210	5.06%	5.0897	11:50	4.7845	10:57	1200
O2	ALM066210	5.03%	5.06	9:01	5.01	10:56	1200
CO2 (stack)	ALM066210	5.06%	4.94	9:01	4.92	10:56	1200
CO (%)	ALM066210	2.50%	2.47	9:01	2.45	10:56	1200

Gas Analyzers Calibrations

Date	8/10/2011
Project	477-S-01-1
Run #	35
Appliance	Coal Stove
Fuel/Burn Rate	Wet Stoker High 2
Personnel	AK/JC/SB
Background	1420-1430
Test Start Time	1447
Test End Time	1823 (6:46 elapsed)
File Name	FNSB - Wet Stoker Coal High 2 - 35

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483 ✓	0	0.1643	1147	0.1491	1831	300
NO	AWB483	0	0.0000	1143	0.0078	1830	↓
NOx	AWB483	0	0.0233	1143	0.0008	1830	
SO2	AWB483	0	0.0957	1143	0.0896	1830	
CO (ppm)	AWB483	0	0.0353	1143	0.5487	1830	
O2	AWB483	0	0.00	1150	0.03	1827	
CO2	AWB483	0	0.00	1150	0.01	1827	
CO (%)	AWB483	0	0.000	1150	0.006	1827	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971✓	465.9	465.9170	1214	396.2620	1830	200
NO	CC5643 ✓	91.08	91.0092	1220	92.1074	1842	~~1400~~ 800
NOx	CC5643 ✓	91.40	91.4249	1220	92.3248	1842	~~1400~~ 800
SO2	CC108971✓	89.8	89.9900	1209	76.5867	1837	200
CO (ppm)	SG9161474	496.5	1158 ↔	493.7640	369.6964	1840	400
O2	Amb. Air	20.95%	20.95	1243	20.92	1826	
CO2	ALM068058	17.10%	17.10	1242	17.02	1854	100
CO (%)	ALM068058	4.28%	4.280	1242	4.260	1854	100

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801 ✓	112.6	118.5102	1234	61.8628	1848	1800
NO	CC287319✓	4.987	5.8091	1238	5.2107	~~5.3178~~ 1851	200
NOx	CC287319✓	5.022	5.9159	1238	5.3178	1851	200
SO2	CC277801✓	21.81	21.3119	1230	20.4156	1846	1800
CO (ppm)	CC287319	20.54	16.8701	1236	16.9645	1851	200
O2	ALM066210	5.03%	5.17	1245	5.06	1853	1200
CO2	ALM066210	5.06%	4.94	1245	4.92	1853	|
CO (%)	ALM066210	2.50%	2.450	1245	2.446	1853	|

Gas Analyzers Calibrations

Pbar = 30.14 in Hg

Date	8/11/2011
Project	477-S-01-1
Run #	36
Appliance	Coal Stove
Fuel/Burn Rate	Wet Lump / Low / cold start
Personnel	AK/JC/SB
Background	9:04 - 9:07
Test Start Time	9:32
Test End Time	17:49

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419
CO2 (tunnel)	0-25 %	220

File Name FNSB_Coal Stove Wet Lump Low Cold_36

NOx filter
9:58 - 10:00
11:01 - 11:02
11:37 - 11:39
11:49 - 11:50

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	AWB483	0	0.1796	8:06	0.6527	5:57	< 200
NO	AWB483	0	0.0108	8:25	0.0017	5:55	↓
NOx	AWB483	0	0.0263	8:25	0.1180	5:55	↓
SO2	AWB483	0	0.3955	8:26	0.0957	5:55	↓
CO (ppm)	AWB483	0	0.0200	8:26	-0.0460	5:55	↓
O2	AWB483	0	0.00	8:58	0.00	6:31	↓
CO2 (stack)	AWB483	0	0.00	8:58	0.03	6:31	↓
CO (%)	AWB483	0	0.00	8:58	0.00	6:31	↓

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	466.4513	8:14	464.3912	5:59	250
NO	CC5643	91.08	91.1129	8:30	90.1123	6:10	500
NOx	CC5643	91.40	91.4219	8:30	90.5280	6:10	500
SO2	CC108971	89.8	89.8799	8:37	82.2225	6:05	250
CO (ppm)	SG9161474	496.5	496.1726	8:43	500.0644	6:16	400
O2	Amb. Air	20.95%	20.94	9:03	20.86	6:30	
CO2 (stack)	ALM068058	17.10%	17.10	9:01	17.01	6:33	700
CO (%)	ALM068058	4.28%	4.28	9:01	4.26	6:33	700

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	113.5352	8:17	120.3566	6:22	1200
NO	CC287319	4.987	4.9146	8:50	4.9116	6:26	200
NOx	CC287319	5.022	5.0279	8:50	4.9242	6:26	200
SO2	CC277801	21.81	21.7188	8:48	21.2140	6:21	1200
CO (ppm)	CC287319	20.54	~~21.0213~~ 19.1128	~~8:47~~ 8:51	18.5176	6:26	200
O2	ALM066210	5.03%	5.02	9:05	5.01	6:35	1200
CO2 (stack)	ALM066210	5.06%	4.98	9:05	4.97	6:35	1200
CO (%)	ALM066210	2.50%	2.46	9:05	2.45	6:35	1200

Torch used 9:35 - 9:37

Gas Analyzers Calibrations

Date	8/12/2011
Project	477-S-01-1
Run #	37
Appliance	Coal Stove
Fuel/Burn Rate	Wet Lump/Low/Hot
Personnel	AK/JC/SB
Background	9:38 - 9:40
Test Start Time	10:05
Test End Time	16:38

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-100 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Coal Stove Wet Lump Low Hot_Gas

ZERO

NOx Filter BMH993

10:35

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	AWB483	0	0.1643	8:56	1.5988	4:45	2600
NO	AWB483	0	0.0078	7:57	0.0078	4:51	
NOx	AWB483	0	0.0141	7:57	0.0233	4:51	
SO2	AWB483	0	0.0000	7:56	0.1936	4:51	
CO (ppm)	AWB483	0	0.0047	7:56	-0.0716	4:52	
O2	AWB483	0	0.00	9:14	-0.05	5:24	
CO2 (stack)	AWB483	0	0.00	9:14	0.01	5:24	
CO (%)	AWB483	0	0.00	9:14	0.00	5:24	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	466.9243	9:03	466.6344	5:12	200
NO	CC5643	91.08	91.1159	8:04	86.7140	4:55	600
NOx	CC5643	91.40	91.4310	8:04	86.6324	4:55	600
SO2	CC108971	89.8	90.4856	8:44	75.3543	5:16	200
CO (ppm)	SG9161474	496.5	495.2416	8:24	489.8499	5:19	400
O2	Amb. Air	20.95%	20.94	9:19	20.86	5:22	
CO2 (stack)	ALM068058	17.10%	17.10	9:16	17.10	5:28	800
CO (%)	ALM068058	4.28%	4.28	9:16	4.28	5:28	800

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	116.5262	9:06	117.3198	5:04	1000
NO	CC287319	4.987	4.8140	8:49	4.8140	4:57	200
NOx	CC287319	5.022	4.9272	8:49	5.0218	4:57	200
SO2	CC277801	21.81	23.1169	8:47	21.1100	5:02	1000
CO (ppm)	CC287319	20.54	18.1055	8:49	19.0212	4:57	200
O2	ALM066210	5.03%	5.06	9:21	4.98	5:26	1150
CO2 (stack)	ALM066210	5.06%	4.98	9:21	4.93	5:26	1150
CO (%)	ALM066210	2.50%	2.51	9:21	2.50	5:26	1150

Gas Analyzers Calibrations

Date	8/15/2011
Project	477-S-01-1
Run #	38
Appliance	Coal Stove
Fuel/Burn Rate	Dry Lump / Low / Hot
Personnel	AK/JC/SB
Background	11:00 – 11:04
Test Start Time	11:51 AM
Test End Time	6:00 PM

Pbar = 30.14 in Hg

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-50 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB_Coal Stove Dry Lump Low Hot_38

NOx filter: 12:13-12:15, 12:49 – 12:51

VOC 12:54

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	BMH993	0	0.1643	9:16	0.1338	6:07	2500
NO	BMH993	0	0.0078	9:11	0.0078	6:04	↓
NOx	BMH993	0	0.0171	9:11	0.0233	6:04	
SO2	BMH993	0	0.1505	9:12	0.0000	6:04	
CO (ppm)	BMH993	0	0.0658	9:12	0.4931	6:05	
O2	BMH993	0	0.00	10:43	0.04	6:09	
CO2 (stack)	BMH993	0	0.00	10:43	0.05	6:09	
CO (%)	BMH993	0	0.00	10:43	0.00	6:09	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	467.7484	9:22	469.7782	6:13	200
NO	CC5643	91.08	91.1129	9:30	90.6492	6:20	600
NOx	CC5643	91.40	91.5195	9:30	91.1290	6:20	600
SO2	CC5643	40.98	40.9779	9:32	40.7237	6:21	600
CO (ppm)	SG9161474	496.5	498.2172	9:47	481.4448	6:24	400
O2	Amb. Air	20.95%	20.94	10:56	20.96	6:08	
CO2 (stack)	ALM068058	17.10%	17.10	10:54	17.05	6:39	
CO (%)	ALM068058	4.28%	4.28	10:54	4.27	6:39	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	112.6806	9:24	116.4042	6:16	1200
NO	CC287319	4.987	4.9146	9:59	4.9177	6:28	200
NOx	CC287319	5.022	5.0218	9:59	5.0218	6:28	200
SO2	CC159390	10.77	10.3459	10:15	10.6440	6:30	1400
CO (ppm)	CC287319	20.54	19.1586	9:59	19.0670	6:29	200
O2	ALM066210	5.03%	5.06	11:00	5.07	6:37	1150
CO2 (stack)	ALM066210	5.06%	4.98	11:00	4.95	6:37	1150
CO (%)	ALM066210	2.50%	2.46	11:00	2.45	6:37	1150

Gas Analyzers Calibrations

Pbar = 30.15 in Hg

Date	8/16/2011
Project	477-S-01-1
Run #	39
Appliance	Coal Stove
Fuel/Burn Rate	
Personnel	AK/JC/SB
Background	8:22
Test Start Time	8:45 (10:11 load)
Test End Time	16:12

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-50 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB - Coal Stove Wet Stoker Low Cold

NOx Filter 9:14 10:15

VOC

ZERO

	Cylinder #	Standard Gas	PRE-CAL Instrument Response	PRE-CAL Time	POST-CAL Instrument Response	POST-CAL Time	End PSI
VOC	BMH993	0	0.1643	7:36	0.6527	4:23	2500
NO	BMH993	0	0.0078	7:29	0.0047	4:21	↓
NOx	BMH993	0	0.0294	7:29	0.1241	4:21	
SO2	BMH993	0	0.3981	7:32	0.0000	4:21	
CO (ppm)	BMH993	0	0.0810	7:29	-0.5600	4:21	
O2	BMH993	0	0.00	8:23	0.03	4:18	
CO2 (stack)	BMH993	0	0.00	8:23	0.04	4:18	
CO (%)	BMH993	0	0.00	8:23	0.00	4:18	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	468.2215	7:44	475.4245	4:25	200
NO	CC5643	91.08	91.1098	8:00	87.5224	4:31	550
NOx	CC5643	91.40	91.4219	8:01	87.2273	4:31	550
SO2	CC5643	40.98	40.9809	7:59	40.7681	4:33	550
CO (ppm)	SG9161474	496.5	495.8216	8:09	468.9752	4:37	300
O2	Amb. Air	20.95%	20.94	8:27	21.03	4:35	
CO2 (stack)	ALM068058	17.10%	17.10	8:26	16.99	4:53	
CO (%)	ALM068058	4.28%	4.28	8:26	4.25	4:53	

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	113.0163	7:46	117.9302	4:27	1200
NO	CC287319	4.987	4.8170	8:04	4.6187	4:43	200
NOx	CC287319	5.022	4.9272	8:04	4.7198	4:43	200
SO2	CC159390	10.77	9.4000	8:17	10.2955	4:41	1400
CO (ppm)	CC287319	20.54	16.7014	8:12	17.0982	4:44	200
O2	ALM066210	5.03%	5.10	8:29	5.12	4:52	1100
CO2 (stack)	ALM066210	5.06%	4.99	8:29	4.93	4:52	1100
CO (%)	ALM066210	2.50%	2.47	8:29	2.45	4:52	1100

Gas Analyzers Calibrations

Date	8/17/2011
Project	477-S-01-1
Run #	40
Appliance	Central-heating indoor furnace
Fuel/Burn Rate	Oil #1
Personnel	AK/JC/SB
Background	12:40-12:42 8/17/11
Test Start Time	12:54 8/17/11
Test End Time	3:41 8/18/11

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-50 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB - Central - Heating Indoor Furnace Oil 1 - 40

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	BMH993	0	0.1338	12:19	0.1643	7:55	2300
NO	BMH993	0	0.0108	11:47	0.0108	8:02	2300
NOx	BMH993	0	0.0237	11:47	0.0202	8:02	↓
SO2	BMH993	0	0.0000	11:51	0.0000	8:02	
CO (ppm)	BMH993	0	0.0963	11:47	-0.3616	8:02	
O2	BMH993	0	0.00	11:22	0.00	7:54	
CO2 (stack)	BMH993	0	0.00	11:22	0.00	7:54	
CO (%)	BMH993	0	0.00	11:22	0.00	7:54	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	465.6572	12:25	480.1095	8:40	<200
NO	CC5643	91.08	91.1129	11:54	87.4156	8:13	300
NOx	CC5643	91.40	91.4219	11:54	87.4195	8:13	300
SO2	CC5643	40.98	40.9763	12:00	39.0243	~~8:13~~ 8:19	300
CO (ppm)	SG9161474	496.5	496.6610	12:04	497.8652	8:22	500
O2	Amb. Air	20.95%	20.94	11:26	20.99	8:07	
CO2 (stack)	ALM068058	17.10%	17.10	11:29	17.15	8:57	700
CO (%)	ALM068058	4.28%	4.28	11:29	4.29	8:57	700

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	113.0623	12:27	108.1782	8:42	1050
NO	CC287319	4.987	4.8140	12:07	4.8170	8:33	800
NOx	CC287319	5.022	5.0248	12:07	4.9242	8:33	300
SO2	CC159390	10.77	10.7983	12:11	9.5956	8:29	1700
CO (ppm)	CC287319	20.54	20.6237	12:07	16.7777	8:34	300
O2	ALM066210	5.03%	5.08	11:33	5.11	8:56	900
CO2 (stack)	ALM066210	5.06%	5.00	11:33	5.01	8:56	900
CO (%)	ALM066210	2.50%	2.47	11:33	2.47	8:56	900

Gas Analyzers Calibrations

Date	8/18/2011
Project	477-S-01-1
Run #	41
Appliance	EPA Wood Stove
Fuel/Burn Rate	Birch/Low/Cold
Personnel	AK/JC/SB
Background	9:08c 10:45-10:47
Test Start Time	10:57 (12:47 load)
Test End Time	15:45

Pbar = 30.25 in Hg

Instrument	Scale	OMNI #
VOC	0-500 ppm	328
NO	0-100 ppm	509
NOx	0-100 ppm	509
SO2	0-50 ppm	329
CO	0-500 ppm	325
CO2 (stack)	0-25 %	419
O2	0-25 %	419
CO (%)	0-5 %	419

File Name FNSB - EPA Stove Birch low cold - 41

ZERO

			PRE-CAL		POST-CAL		
	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	BMH993	0	0.1643	8:00	0.6832	3:54	2300
NO	BMH993	0	0.0078	8:04	0.0047	3:56	↓
NOx	BMH993	0	0.0171	8:04	0.0263	3:56	
SO2	BMH993	0	0.0481	8:04	0.0000	3:56	
CO (ppm)	BMH993	0	0.1726	8:06	0.0505	3:56	
O2	BMH993	0	0.00	7:59	0.08	3:54	
CO2 (stack)	BMH993	0	0.00	7:59	0.07	3:54	
CO (%)	BMH993	0	0.00	7:59	0.00	3:53	

SPAN

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC108971	465.9	466.8938	8:46	471.6240	4:21	<200
NO	CC5643	91.08	91.1129	8:19	89.6120	3:59	300
NOx	CC5643	91.40	91.4219	8:19	89.7257	3:59	300
SO2	CC5643	40.98	40.9763	8:20	37.7153	4:00	300
CO (ppm)	SG9161474	496.5	496.7526	8:24	492.1740	4:03	300
O2	Amb. Air	20.95%	20.94	8:07	20.90	3:58	
CO2 (stack)	ALM068058	17.10%	17.10	8:58	17.05	4:32	650
CO (%)	ALM068058	4.28%	4.28	8:58	4.26	4:32	650

LOW CHECK

	Cylinder #	Standard Gas	Instrument Response	Time	Instrument Response	Time	End PSI
VOC	CC277801	112.6	112.1007	8:49	111.0324	4:23	1050
NO	CC287319	4.987	4.8140	8:35	4.8170	4:06	250
NOx	CC287319	5.022	4.9272	8:35	4.9272	4:06	250
SO2	CC159390	10.77	9.7484	8:30	10.0983	4:14	1400
CO (ppm)	CC287319	20.54	16.7929	8:35	21.1274	4:05	250
O2	ALM066210	5.03%	5.12	8:59	5.12	4:28	900
CO2 (stack)	ALM066210	5.06%	5.02	8:59	4.98	4:28	900
CO (%)	ALM066210	2.50%	2.47	8:59	2.45	4:28	900

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI99E15A4BQ4	Reference Number:	48-124250190-4
Cylinder Number:	CC276183	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	Jan 31, 2011

Expiration Date: Jan 31, 2013

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	22.00 PPM	22.27 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	22.00 PPM	22.20 PPM	G1	+/- 1% NIST Traceable
SULFUR DIOXIDE	45.00 PPM	45.14 PPM	G1	+/- 1% NIST Traceable
PROPANE	225.0 PPM	225.4 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	080601	CC237959	50.60PPM SULFUR DIOXIDE/NITROGEN	Dec 15, 2011
NTRM	100603	CC280968	20.34PPM NITRIC OXIDE/NITROGEN	Feb 01, 2013
NTRM	100603NOx	CC280968	20.36PPM NOx/NITROGEN	Feb 01, 2013
NTRM	990605	XC012013B	248.9PPM PROPANE/	Oct 02, 2011

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
California Analytical NO	CLD NO	Jan 14, 2011
California Analitical NOx	CLD NOx	Jan 14, 2011
Nicolet 6700 AHR0801551 C3H8	FTIR	Jan 13, 2011
Nicolet 6700 AHR0801551 SO2	FTIR	Jan 15, 2011

Triad Data Available Upon Request

Notes:

Signature on file

Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E03NI99E15A03N0	Reference Number:	48-124290510-3
Cylinder Number:	CC280202	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	Nov 17, 2011

Expiration Date: Nov 17, 2013

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	9.000 PPM	8.897 PPM	G1	+/- 1% NIST Traceable
CARBON MONOXIDE	9.000 PPM	8.865 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	9.000 PPM	8.866 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	100603	CC253524	20.34PPM NITRIC OXIDE/NITROGEN	Feb 01, 2013
NTRM	100603	CC253524NOx	20.36PPM NOx/NITROGEN	Feb 01, 2013
NTRM	080609	CC255507	10.04PPM CARBON MONOXIDE/NITROGEN	Jun 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700 AHR0801551 CO	FTIR	Nov 07, 2011
Thermo 42i-LS	Chemiluminescence	Nov 12, 2011
Thermo 42i-LS NOx	Chemiluminescence	Nov 12, 2011

Triad Data Available Upon Request

Notes:

Signature on file

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Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI77E15A0575	Reference Number:	48-124241253-1
Cylinder Number:	CC75242	Cylinder Volume:	151 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	590
		Analysis Date:	Nov 18, 2010

Expiration Date: Nov 18, 2013

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
CARBON MONOXIDE	2.500 %	2.512 %	G1	+/- 1% NIST Traceable
CARBON DIOXIDE	10.00 %	10.17 %	G1	+/- 1% NIST Traceable
OXYGEN	10.50 %	10.56 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	080614	CC267714	1.959% CARBON MONOXIDE/NITROGEN	Oct 15, 2012
NTRM	980510	SG9168397	12.05% OXYGEN/NITROGEN	Jan 15, 2012
NTRM	970510	SG9198971	10.818% CARBON DIOXIDE/NITROGEN	May 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
SIEMENS % CO2	NDIR	Oct 15, 2010
HORIBA % CO	NDIR	Nov 12, 2010
Siemens %O2	PARAMAGNETIC	Oct 15, 2010

Triad Data Available Upon Request

Notes:

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Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI97E15A47Z4	Reference Number:	54-124196695-12
Cylinder Number:	CC287319	Cylinder Volume:	145 Cu.Ft.
Laboratory:	ASG - Chicago - IL	Cylinder Pressure:	2015 PSIG
PGVP Number:	B12011	Valve Outlet:	660
		Analysis Date:	Nov 13, 2009

Expiration Date: Nov 13, 2011

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	5.000 PPM	5.022 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	5.000 PPM	4.987 PPM	G1	+/- 1% NIST Traceable
CARBON MONOXIDE	20.00 PPM	20.54 PPM	G1	+/- 1% NIST Traceable
CARBON DIOXIDE	2.000 %	1.984 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM/NO	1	CC207744	10.08PPM NITRIC OXIDE/	Sep 01, 2011
NTRM/NOX	07060317NOX	CC207744	10.16PPM NOx/NITROGEN	Sep 01, 2011
NTRM/CO	51008	SG9154067	25.50PPM CARBON MONOXIDE/	Oct 02, 2010
NTRM/CO2	970507	SG9182105BAL	4.204% CARBON DIOXIDE/NITROGEN	May 01, 2010

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
(CO-1)HORIBA VIA-510	NDIR	Oct 21, 2009
(CO-1)HORIBA VIA-510	NDIR	Oct 21, 2009
(CH-1) CAI Model 600	Chemiluminescence	Oct 21, 2009
(CH-1) CAI Model 600	Chemiluminescence	Oct 21, 2009

Triad Data Available Upon Request

Notes:

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CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI99E15A25V2	Reference Number:	48-124265918-3
Cylinder Number:	CC159390	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	May 27, 2011

Expiration Date: Nov 27, 2011

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	5.000 PPM	4.916 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	5.000 PPM	4.832 PPM	G1	+/- 1% NIST Traceable
SULFUR DIOXIDE	11.00 PPM	10.77 PPM	G1	+/- 1% NIST Traceable
PROPANE	55.00 PPM	57.33 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	080610	CC263076	49.62PPM PROPANE/AIR	Jul 15, 2012
NTRM	100603	CC280968	20.34PPM NITRIC OXIDE/NITROGEN	Feb 01, 2013
NTRM	100603NOx	CC280968	20.36PPM NOx/NITROGEN	Feb 01, 2013
NTRM	100601	CC284502	14.82PPM SULFUR DIOXIDE/NITROGEN	Jul 13, 2013

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
California Analytical NO	CLD NO	May 19, 2011
California Analitical NOx	CLD NOx	May 19, 2011
Nicolet 6700 AHR0801551 C3H8	FTIR	May 23, 2011
Nicolet 6700 AHR0801551 SO2	FTIR	May 23, 2011

Triad Data Available Upon Request

Notes:

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CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E02NI99E15A03L6	Reference Number:	48-124155105-1
Cylinder Number:	SG9161474	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	590
		Analysis Date:	Oct 21, 2008

Expiration Date: Oct 21, 2011

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
CARBON MONOXIDE	490.0 PPM	496.5 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	05120506	CC180354	495.8PPM CARBON MONOXIDE/NITROGEN	Feb 02, 2009

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
SIEMENS CO LOW	NDIR	Oct 17, 2008

Triad Data Available Upon Request

Notes:

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CERTIFICATE OF ANALYSIS

Grade of Product: CERTIFIED STANDARD-SPEC

Part Number:	X05NI99C15AC524	Reference Number:	48-124231541-1
Cylinder Number:	CC5643	Cylinder Volume:	144.4 Cubic Feet
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
Analysis Date:	Aug 25, 2010	Valve Outlet:	660

Product composition verified by direct comparison to calibration standards traceable to NIST ASTM Class 1 weights and/or NIST gas mixture reference materials.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration (Mole %)	(Volume %)	Analytical Uncertainty
SULFUR DIOXIDE	40.00 PPM	40.98 PPM	40.98	+/- 5%
CARBON MONOXIDE	90.00 PPM	92.05 PPM	92.05	+/- 2%
NITRIC OXIDE	90.00 PPM	91.08 PPM	91.08	+/- 2%
PROPANE	90.00 PPM	93.56 PPM	93.56	+/- 2%
NITROGEN	Balance			
Total oxides of nitrogen		91.40 PPM	For Reference Only	

Notes:

Signature on file

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Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI99E15A2VF3	Reference Number:	48-124250190-2
Cylinder Number:	CC277801	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	Feb 02, 2011

Expiration Date: Aug 02, 2011

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	10.00 PPM	10.53 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	10.00 PPM	10.53 PPM	G1	+/- 1% NIST Traceable
SULFUR DIOXIDE	22.00 PPM	21.81 PPM	G1	+/- 1% NIST Traceable
PROPANE	112.0 PPM	112.6 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	080605	CC208113	14.92PPM SULFUR DIOXIDE/NITROGEN	May 01, 2012
NTRM	090607	CC253474	9.90PPM NITRIC OXIDE/NITROGEN	Oct 02, 2011
NTRM	090607NOx	CC253474	9.90PPM NOx/NITROGEN	Oct 02, 2011
NTRM	090617	CC301753	97.82PPM PROPANE/AIR	Oct 02, 2013

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
California Analytical NO	CLD NO	Jan 14, 2011
California Analitical NOx	CLD NOx	Jan 14, 2011
Nicolet 6700 AHR0801551 C3H8	FTIR	Jan 13, 2011
Nicolet 6700 AMP0900118 SO2	FTIR	Jan 07, 2011

Triad Data Available Upon Request

Notes:

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Page 1 of 48-124250190-2

Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI61E15A0574	Reference Number:	54-124246819-1
Cylinder Number:	CC337886	Cylinder Volume:	101 Cu.Ft.
Laboratory:	ASG - Chicago - IL	Cylinder Pressure:	1310 PSIG
PGVP Number:	B12011	Valve Outlet:	590
		Analysis Date:	Jan 12, 2011

Expiration Date: Jan 12, 2014

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
CARBON MONOXIDE	4.250 %	4.327 %	G1	+/- 1% NIST Traceable
CARBON DIOXIDE	17.00 %	16.76 %	G1	+/- 1% NIST Traceable
OXYGEN	17.00 %	16.68 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM/O2	06060810	CC206131	22.51% OXYGEN/NITROGEN	May 01, 2016
NTRM/CO2	08061328	CC255569	20.09% CARBON DIOXIDE/	Jul 15, 2012
NTRM/CO	91508	CC269453	7.976% CARBON MONOXIDE/NITROGEN	Jul 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
(CO2-1)HORIBA VIA-510	NDIR	Dec 28, 2010
(CO-2)HORIBA VIA-510	NDIR	Dec 28, 2010
(O2-1)HORIBA MPA-510	Paramagnetic	Jan 04, 2011

Triad Data Available Upon Request

Notes:

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Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E04NI99E15A3LS0	Reference Number:	48-124265918-4
Cylinder Number:	CC108971	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	Jun 02, 2011

Expiration Date: Jun 02, 2013

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NITRIC OXIDE	45.00 PPM	46.25 PPM	G1	+/- 1% NIST Traceable
SULFUR DIOXIDE	90.00 PPM	89.80 PPM	G1	+/- 1% NIST Traceable
PROPANE	450.0 PPM	465.9 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			
Total oxides of nitrogen		46.45 PPM		For Reference Only

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	080615	CC255671	94.67PPM SULFUR DIOXIDE/NITROGEN	Oct 15, 2012
NTRM	100605	CC281711	495.3PPM PROPANE/NITROGEN	Feb 19, 2016
NTRM	100611	CC283982	49.73PPM NITRIC OXIDE/NITROGEN	Jul 23, 2016

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700 AHR0801551 NO	FTIR	May 23, 2011
Nicolet 6700 AHR0801551 C3H8	FTIR	May 25, 2011
Nicolet 6700 AMP0900118 SO2	FTIR	May 12, 2011

Triad Data Available Upon Request

Notes:

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Approved for Release

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E03NI99E15A0801	Reference Number:	48-124271954-2
Cylinder Number:	CC261974	Cylinder Volume:	144 Cu.Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
PGVP Number:	B32011	Valve Outlet:	660
		Analysis Date:	Jul 07, 2011

Expiration Date: Jul 07, 2013

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
NOx	9.000 PPM	8.959 PPM	G1	+/- 1% NIST Traceable
NITRIC OXIDE	9.000 PPM	8.876 PPM	G1	+/- 1% NIST Traceable
CARBON MONOXIDE	18.00 PPM	18.24 PPM	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	100603	CC280968	20.34PPM NITRIC OXIDE/NITROGEN	Feb 01, 2013
NTRM	100603NOx	CC280968	20.36PPM NOx/NITROGEN	Feb 01, 2013
NTRM	090618	CC282592	24.35PPM CARBON MONOXIDE/NITROGEN	Oct 02, 2013

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
SIEMENS CO LOW	NDIR	Jun 28, 2011
Thermo 42i-LS	Chemiluminescence	Jun 14, 2011
Thermo 42i-LS NOx	Chemiluminescence	Jun 14, 2011

Triad Data Available Upon Request

Notes:

Signature on file

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AIR LIQUIDE Air Liquide America Specialty Gases LLC Scott™

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501 Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42011

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: OTL-11-036
Document # : 41897724-002

Customer
OMNI-TEST LABS

CINDI WARREN
13327 NE AIRPORT WAY
PORTLAND OR 97230
US

ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: ALM068058 **Certification Date:** 07Jun2011 **Exp. Date:** 06Jun2014
Cylinder Pressure*:** 2000 PSIG

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ACCURACY**	TRACEABILITY
CARBON MONOXIDE	4.28	%	+/- 1%	Direct NIST and VSL
CARBON DIOXIDE	17.1	%	+/- 1%	Direct NIST and VSL
OXYGEN	17.0	%	+/- 1%	Direct NIST and VSL
NITROGEN		BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 2639	02Dec2011	KAL004146	0.974 %	CARBON MONOXIDE
NTRM 1800	01Mar2013	K022438	17.87 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
HP/6890/US00034440	23May2011	TCD/FID
HPGC/5890/3115A34624	01Jun2011	TCD
OXYMAT/6E/W5-951	13May2011	PARAMAGNETIC

ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

First Triad Analysis | **Second Triad Analysis** | **Calibration Curve**

CARBON MONOXIDE

First Triad Analysis
Date: 31May2011 Response Unit:AREA
Z1=0.00000 R1=1654120. T1=7242134.
R2=1645357. Z2=0.00000 T2=7248966.
Z3=0.00000 T3=7243511. R3=1642780.
Avg. Concentration: 4.277 %

Second Triad Analysis
Date: 07Jun2011 Response Unit: AREA
Z1=0.00000 R1=1663220. T1=7328961.
R2=1668983. Z2=0.00000 T2=7335004.
Z3=0.00000 T3=7325979. R3=1661074.
Avg. Concentration: 4.283 %

Calibration Curve
Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999999
Constants: A=0.00193103
B=5.8855E-07 C=
D= E=

CARBON DIOXIDE

Date: 11Jun2011 Response Unit:AREA
Z1=0.00000 R1=429828.0 T1=412982.0
R2=430386.0 Z2=0.00000 T2=411942.0
Z3=0.00000 T3=411738.0 R3=430391.0
Avg. Concentration: 17.11 %

Concentration=A+Bx+Cx2+Dx3+Ex4
r=1.000000
Constants: A=-0.00272576
B=4.07397E-05 C=
D= E=

OXYGEN

Date: 02Jun2011 Response Unit:VOLTS
Z1=0.00000 R1=10.14000 T1=17.08000
R2=10.10000 Z2=0.00000 T2=17.07000
Z3=0.00000 T3=17.04000 R3=10.08000
Avg. Concentration: 16.99 %

Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999998
Constants: A=0.00691632
B=0.998636028 C=
D= E=

APPROVED BY: JOHN ROZOF

G66

AIR LIQUIDE Air Liquide America Specialty Gases LLC Scott

RATA CLASS

Dual-Analyzed Calibration Standard

500 WEAVER PARK RD, LONGMONT, CO 80501

Phone: 888-253-1635 Fax: 303-772-7673

CERTIFICATE OF ACCURACY: EPA Protocol Gas

Assay Laboratory - PGVP Vendor ID: A42011

AIR LIQUIDE AMERICA SPECIALTY GASES LLC
500 WEAVER PARK RD
LONGMONT, CO 80501

P.O. No.: OTL-11-036
Document # : 41897724-001

Customer
OMNI-TEST LABS

CINDI WARREN
13327 NE AIRPORT WAY
PORTLAND OR 97230
US

ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: ALM066210 Certification Date: 07Jun2011 Exp. Date: 06Jun2014
Cylinder Pressure***: 2000 PSIG

COMPONENT	CERTIFIED CONCENTRATION (Moles)	ACCURACY**	TRACEABILITY
CARBON MONOXIDE	2.50 %	+/- 1%	Direct NIST and VSL
CARBON DIOXIDE	5.06 %	+/- 1%	Direct NIST and VSL
OXYGEN	5.03 %	+/- 1%	Direct NIST and VSL
NITROGEN	BALANCE		

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.

REFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 2639	02Dec2011	KAL004146	0.974 %	CARBON MONOXIDE
NTRM 1800	01Mar2013	K022438	17.87 %	CARBON DIOXIDE
NTRM 2658	01Feb2016	K012175	10.03 %	OXYGEN

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
HP/6890/US00034440	23May2011	TCD/FID
HPGC/5890/3115A34624	01Jun2011	TCD
OXYMAT/6E/W6-951	13May2011	PARAMAGNETIC

ANALYZER READINGS

(Z=Zero Gas R=Reference Gas T=Test Gas r=Correlation Coefficient)

CARBON MONOXIDE

First Triad Analysis
Date: 31May2011 Response Unit:AREA
Z1=0.00000 R1=1654120. T1=4244090.
R2=1645357. Z2=0.00000 T2=4226329.
Z3=0.00000 T3=4224092. R3=1642780.
Avg. Concentration: 2.499 %

Second Triad Analysis
Date: 07Jun2011 Response Unit: AREA
Z1=0.00000 R1=1663220. T1=4273573.
R2=1668983. Z2=0.00000 T2=4268895.
Z3=0.00000 T3=4269862. R3=1661074.
Avg. Concentration: 2.496 %

Calibration Curve
Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999999
Constants: A=0.00193103
B=5.8855E-07 C=
D= E=

CARBON DIOXIDE

Date: 01Jun2011 Response Unit:AREA
Z1=0.00000 R1=429828.0 T1=123841.0
R2=430386.0 Z2=0.00000 T2=122887.0
Z3=0.00000 T3=123868.0 R3=430391.0
Avg. Concentration: 5.060 %

Concentration=A+Bx+Cx2+Dx3+Ex4
r=1.000000
Constants: A=-0.00272576
B=4.07397E-05 C=
D= E=

OXYGEN

Date: 02Jun2011 Response Unit:VOLTS
Z1=0.00000 R1=10.14000 T1=5.04800
R2=10.10000 Z2=0.00000 T2=5.05300
Z3=0.00000 T3=5.04300 R3=10.08000
Avg. Concentration: 5.030 %

Concentration=A+Bx+Cx2+Dx3+Ex4
r=0.999998
Constants: A=0.00691632
B=0.998836028 C=
D= E=

APPROVED BY: [signature]
JOHN ROZOF

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