III.K.5 EMISSION INVENTORY

Given the characterizations of existing regional haze levels at each of the Class I monitors, a series of emission inventories were developed for the entire state of Alaska upon which to base the regional haze air quality modeling and reasonable further progress demonstration.

This section discusses the development of these Alaska Regional Haze emission inventories. It addresses selection of the analysis years and scenarios to support the subsequent modeling and reasonable further progress demonstration, the pollutants included in the inventories, the scope and extent of included sources, the data sources and methods used to develop individual emission estimates, and the processing/formatting that was performed to configure the inventories into useful modeling datasets.

A. Baseline and Future-Year Emissions Inventories for Modeling

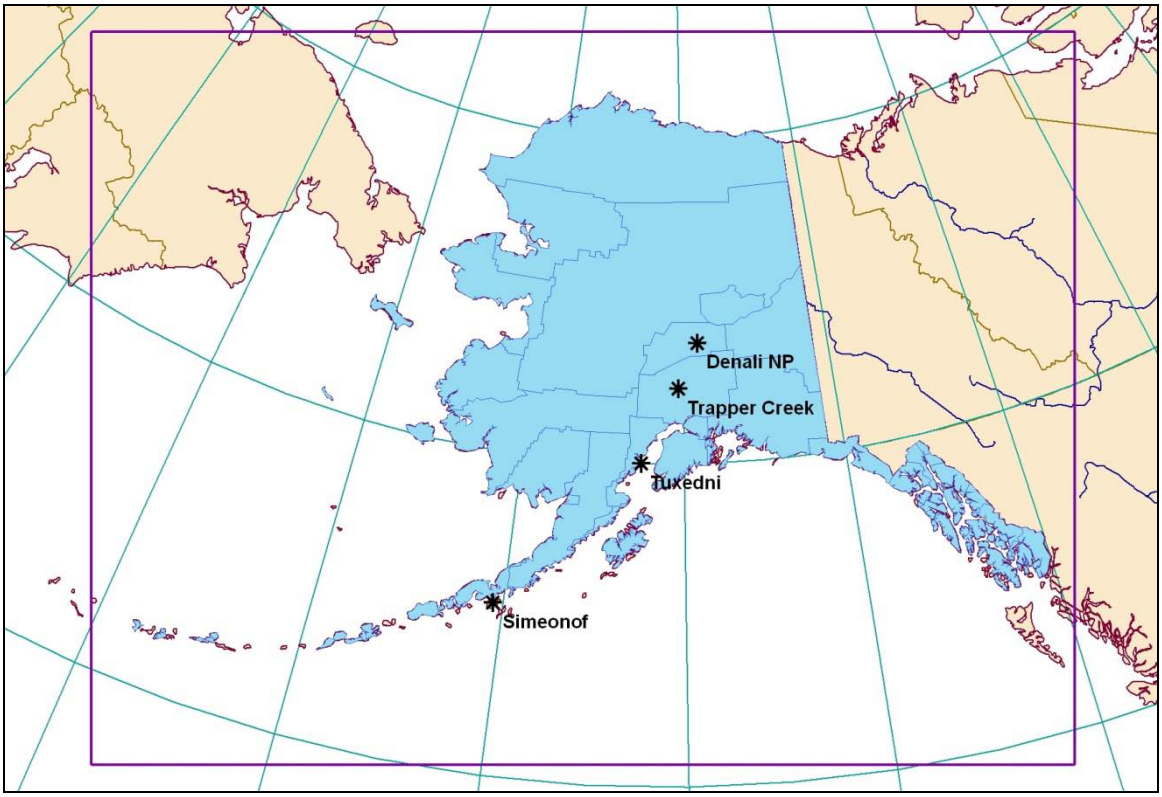
A series of pollutant emission inventories were developed to support the modeling analysis conducted for the SIP. Key issues that were considered in the development of these region haze emission inventories are outlined below.

- *Pollutants* – Inventories were developed for the following pollutants: hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur oxides (SOx), ammonia (NH_3), and coarse and fine particulate matter (PM_{10} and $PM_{2.5}$, respectively). Although CO is not considered a pollutant that affects regional haze, it was included in the inventories developed to support this effort because it was contained in supporting inventory datasets from previous Alaska inventory studies. It was generally simpler to retain it in these inventories, but not include it in subsequent products (e.g., the Weighted Emissions Potential analysis described in Section III.K.7).

- *Areal Extent* – The inventories represent sources within the entire state of Alaska, encompassing a total of 27 boroughs/counties.[*] Figure III.K.5-1 shows the extent of the rectangular modeling domain for which the inventories were developed, along with the locations of the four Class I monitoring sites in Alaska. Even though this rectangular domain extends into portions of Canada, emissions from Canadian sources were not included. In addition, as discussed in Section III.K.5.D, emissions that are potentially transported to Alaska from other areas such as Asia and Russia were also excluded.

[*] What are referred to as "counties" in the contiguous states within the U.S. are termed "boroughs," "municipalities" or "census areas" in Alaska. From this point forward, they are referred to interchangeably.

Figure III.K.5-1
Areal Extent of Alaska Regional Haze Modeling Domain



- *Included Sources* – Emission sources included all known* stationary point and area sources including fugitive dust and both anthropogenic and natural fires and on-road and non-road mobile sources. As discussed later in this section, biogenic and geogenic sources were not included.

- *Calendar Years* – Emission inventories were developed for two calendar years: 2002 and 2018. As explained in Section III.K.5.B, the 2002 inventory is intended to represent emissions during the 2000-2004 five-year average baseline period defined in the Regional Haze Rule. The calendar year 2018 forecasted inventory represents the end of the implementation period for the initial SIP.

- *Temporal Resolution* – The inventories were expressed in the form of annual emissions for the two calendar years listed. However, for all source sectors except stationary point

* All known point area and mobile sources were included with one exception: non-road locomotives. Locomotive emissions in Alaska were obtained from the WRAP in the form of summarized calendar year 2002 and 2018 totals for the entire state. Emissions from locomotives represented less than 0.7% of total statewide emissions for all pollutants, including NOx. Given their relatively minor emission levels and lack of a spatial dataset other than a railroad track centerline layer to distribute locomotive activity and emissions, they were not included in these inventories.

sources and fires, they were developed by summing separate six-month winter and summer season emissions. In many cases, these underlying winter and summer seasonal inventories were developed based on season-specific activity levels and ambient conditions. (Seasonal representation is especially important in Alaska where ambient conditions and activity levels for particular source categories vary significantly over a yearly period.)

- *Spatial Resolution* – Emissions throughout the state were allocated into individual 45-kilometer square grid cells over the rectangular domain shown in Figure III.K.5-1. Depending on the source sector, techniques differed in how emissions were spatially resolved and allocated to grid cells as explained later under Section III.K.5.E.

Given this overview, specific elements of the 2002 baseline and 2018 forecasted inventories are described below.

B. 2002 Baseline Inventory

As described in the Regional Haze Rule,[41] the baseline inventory (and baseline visibility characterizations) should be developed in a manner that, to the extent feasible, represents an average of annual emissions over the period from 2000-2004. The intent is to account for emission sources or events with potentially large variations from year to year that can affect visibility and regional haze. For certain source categories, significant variations in activity (and emissions) can occur. This is especially true in Alaska, where differences in annual emissions from sources such as wildfires or geogenic activity from one year to the next can be substantial, and significantly affect regional haze characterizations depending on how the irregular annual activity from such sources are accounted for.

Therefore, the fire sector of the baseline inventory was developed using 2000-2004 average data obtained from the WRAP Fire Inventory efforts.[42] These data reflect fire activity (from wildfires, wildland fires, and prescribed burns) averaged over this five-year period and likely reflect a less biased estimate of baseline fire emissions than activity in a given individual year. Prescribed fire acreage is typically less that five percent of the entire burned acreage.

For the remaining source categories, the baseline inventory was represented using calendar year 2002 annual activity and emission estimates. For these remaining categories, there is much less "random" variation in source activity from year to year, although in most cases, there are consistent trends in activity for sources related to population, employment or travel (e.g., vehicle miles). For these categories, activity levels that reflect the year 2002 midpoint of the 2000-2004 baseline provide a good estimate of average annual activity over that period. These 2002 activity levels were either directly estimated for specific sources or backcasted from calendar year 2005 levels using trends in county-wide population from 2002 to 2005.

C. 2018 Future-Year Inventory

The 2018 inventory was developed to reflect emission levels projected to calendar year 2018, accounting for forecasted changes in source activity and emission factors. Population projections[43] compiled by the Alaska Department of Labor and Workforce Development (DOLWD) at five-year intervals through 2030 by individual borough and census area were used to grow 2002 baseline activity to 2018 for most of the source categories, with a couple of exceptions.

First, fire sector emissions for wildfires were held constant, reflecting the fact that one cannot reasonable forecast any change in wildfire activity through the state between 2002 and 2018. (As explained later, modest reductions in prescribed burn emissions were assumed, consistent with WRAP 2018b Phase III Fire Inventory forecast.) Second, activity from small port commercial marine vessel activity in 2002 was assumed to be identical to that obtained for calendar year 2005.

Emission factors specific to calendar year 2018 were also developed for source sectors affected by regulatory control programs and technology improvements. These source sectors included on-road and non-road mobile sources (except commercial marine vessels and aviation) and stationary point sources.

While the methodology adopted to forecast the 2018 inventory ensures that there is continuity in the emission sources and activity levels represented, it fails to account for structural changes that will occur. For example, within the stationary source sector, some of the point sources operating in 2002 have already shut down; nevertheless their emissions are forecast to grow in proportion to the population growth rate. Similarly, new and or permitted sources that are not currently operating may be in operation in 2018 and their emissions are not included in the 2018 forecast. An example of a source that has shut down is the Agrium facility located in the Kenai. An example of a permitted source that did not operate in 2002, is not currently operating, but could operate in future years is the Healy Clean Coal Project (HCCP). To the extent that the status of these and other facilities are known their impact on forecasted emissions and visibility will be discussed to provide a more accurate view of potential impacts.

D. Inventories for Specific Source Categories

The regional haze emission inventories were developed largely by integrating emission estimates from a series of earlier inventory efforts[44,45,46,47,48] prepared for specific source sectors and areas within Alaska. These inventory studies were commissioned by ADEC or developed in conjunction with WRAP for criteria pollutant SIP planning and routine reporting purposes, but also with an eye toward representing 2002 and 2018 emissions for all key source sectors statewide for this Regional Haze SIP. Thus, a key component of this effort consisted of assembling these separate inventory datasets into a complete, unified structure that properly accounted for emissions across the entire state for all included source sectors.

Table III.K.5-1 shows the coverage of each of these earlier inventory "components" by source sector and area of the state. For the purpose of combining these earlier study datasets together and as indicated in Table III.K.5-1, the state is represented in three geographic regions:

1. "Big 3" boroughs/counties of Anchorage, Fairbanks and Juneau;
2. Remaining 24 borough/counties; and
3. Large Ports (which is not mutually exclusive and spans both county groups).

As indicated at the bottom left of Table III.K.5-1, fire emissions were represented using the Phase III Fire Inventories obtained from the WRAP and were categorized by fire type (e.g., wildfire, wildland fire, prescribed burn) and an indication of whether it was anthropogenic or natural in origin/cause. As seen in the resulting inventory tabulations, it was critical both to distinguish between anthropogenic and natural fires and to account for the sizable contribution of natural fires within the Alaska Regional Haze inventories.

Table III.K.5-1
Summary of Regional Haze Emission Inventory Components

<table>
<tr><th rowspan="2">Source Sector</th><th colspan="3">Geographic Area in Alaska</th></tr>
<tr><th>Anchorage, Fairbanks, Juneau</th><th>Remaining 24 Boroughs & Census Areas</th><th>Nine Major Ports</th></tr>
<tr><td>Area (excl. wildfires)</td><td rowspan="3">DEC "Big 3"Criteria Pollutant Inventories</td><td rowspan="4">WRAP 2005, 2018 Representative Communities Inventories</td><td>n/a</td></tr>
<tr><td>Non-Road Mobile (excl. Commercial Marine Vessels & Aviation)</td><td>n/a</td></tr>
<tr><td>On-Road Mobile</td><td>n/a</td></tr>
<tr><td>Commercial Marine Vessels</td><td>Anchorage & Juneau from Pechan inventories</td><td>Pechan Alaskan Port 2002, 2005, 2018 Commerical Marine Vessels Inventories</td></tr>
<tr><td>Aviation (aircraft, ground support equipment)</td><td colspan="2">WRAP 2002 Aviation Inventory</td><td>n/a</td></tr>
<tr><td>Point</td><td colspan="2">WRAP 2002 and 2018 Point Source Inventories</td><td>n/a</td></tr>
<tr><td>Fires, Anthro & Natural</td><td colspan="2">WRAP 2002, 2018 Phase III Fire Inventories</td><td>n/a</td></tr>
</table>

n/a – not applicable

Once the inventory data from these earlier studies were assembled into a series of unified datasets covering both the 2002 baseline and 2018 forecast calendar years, initial tabulations were developed to examine emissions by pollutant, county, and source sector. Review of these initial tabulations revealed the need to re-examine some of the growth assumptions that were used to project 2018 emissions in the original studies, ensure specific sources were not double-counted, and refine assumptions that were used to extrapolate county-wide emissions from small community emission surveys for specific counties.

A series of revisions/updates to the originally developed inventory datasets were applied to address these issues and are described in detail as follows.

1. 2002-2018 Growth Revisions

The population forecast employed in the Representative Community Emission Inventory was based on a 2005 forecast from the Alaska Department of Commerce.[*] More recent estimates of the 2005 base year population levels and 2018 forecasts show surprising differences. This discussion focuses on the two boroughs identified in the WEP (weight emission potential) analysis as having the greatest anthropogenic impact on Class I areas: Mat-Su and Kenai. Table III.K.5-2 compares the 2005 estimates and 2018 forecasts available at the time of the Representative Community analysis and more recent estimates. It shows that Mat-Su grew more rapidly in 2005 than originally estimated and that the forecast for 2018 has diminished considerably. The Kenai, on the other hand, shows little change in the 2005 population estimate,

Table III.K.5-2
Changes in 2005 Population Estimates and 2018 Forecasts

Borough	Projection Source	2005	2018	Rate
Mat-Su	Dept. Commerce – 2005	67,210	123,616	1.84
	Dept. Labor – 2007/2008	73,984	105,823	1.43
Kenai	Dept. Commerce – 2005	51,133	62,487	1.22
	Dept. Labor – 2007/2008	51,172	57,102	1.12

but a substantial change in 2018 forecast. Overall, the current forecasts of growth are roughly half the values used in the Representative Community analysis. Since similar reductions were observed for other boroughs, the population forecasts used to drive the 2018 emission estimates for all communities and boroughs were updated with the more current estimates.

Two separate reports from the Department of Labor were used to update the population estimates: the first provides population values by borough between 1990 and 2008;[49] the second provides an updated forecast of population by borough between 2007 and 2030.[50] Three separate forecasts are available: low, middle, and high. The middle values were used to update the emission inventory forecasts.

2. Revisions to Anchorage, Fairbanks, and Juneau Emission Estimates

Emission estimates for Anchorage, Fairbanks, and Juneau included in the Regional Haze emissions inventory came from the Criteria Pollutant Inventory.[51] That effort produced estimates of on-road, non-road and area source emissions. A review of the study found that

[*] 2000 Census Population and 2005 State Demographer Estimated Population, Alaska Department of Commerce, Community, and Economic Development, Community Database Online *http://www.dced.state.ak.us/dca/commdb/CF_COMDB.htm*, September 2006.

wildfire emissions were included for summer months only in the area source estimates. Since wildfire emissions are addressed separately in the Regional Haze inventory, these values were netted out of the emission estimates for Anchorage, Fairbanks, and Juneau.

The previously cited population forecasts used to project growth for the boroughs addressed in the Representative Community analysis were used to update the forecasts for Anchorage, Fairbanks, and Juneau. Table III.K.5-3 compares the values used in the Criteria Pollutant Inventory and the updated values. As can be seen, the growth rates for Anchorage and Fairbanks have increased, while the Juneau growth declined.

Table III.K.5-3
Changes in 2003 Population Estimates and 2018 Forecasts

Borough	Projection Source	2003	2018	Rate
Anchorage	Dept. Labor 1998 - 2018	269,567	298,875	1.11
	Dept. Labor – 2007/2008	271,031	315,925	1.17
Fairbanks	Dept. Labor 1998 – 2018	88,012	98,585	1.12
	Dept. Labor – 2007/2008	85,652	100,244	1.17
Juneau	Dept. Labor 1998 – 2018	31,388	34,447	1.10
	Dept. Labor – 2007/2008	31,047	32,182	1.04

3. Revisions to the Mat-Su and Kenai Emission Estimates

The emission estimates for these boroughs were examined in detail and found to be substantially greater (5-20 times) than the estimates for Anchorage, the most populated borough in the state. The reason is that surrogate communities selected to represent communities in these boroughs, from the Representative Community study, do not well represent the infrastructure available to these boroughs.[*] Key differences are outlined below.

- Most Mat-Su and Kenai communities have access to natural gas from Enstar for space heat. The surrogate communities did not and burned a mixture of distillate fuel oil and wood for space heat, which significantly overstated emissions from space heating.

- All of the representative and surrogate communities include significant levels of fugitive dust from vehicle operations on unpaved roads, whereas most of the roads in the Mat-Su and Kenai communities are paved.

- All the representative and surrogate communities include significant amounts of utility emissions from Diesel generators. Almost all of the communities within Mat-Su and Kenai Boroughs are on the grid from:

[*] That study conducted a detailed survey of activity and fuel use in 13 communities stratified to represent all areas outside of Anchorage, Fairbanks, and Juneau (communities with the largest populations). The results from the surveyed communities were then extrapolated to all communities outside of the three major population centers.

- Chugach Electric,
- Mat-Su Electric,
- Homer Electric,
- Seward Electric, or
- Combinations of the above

Most of the power for these grids, which are interconnected, come from natural gas and hydro power plants. Most, but not all, are located in Anchorage and qualify as major point sources; emissions from these facilities have already been addressed in the Regional Haze inventory. The remaining facilities in Mat-Su and Kenai do not qualify as major point sources.

To address the overestimation of the emissions from communities located within Mat-Su and Kenai Boroughs, new surrogates were identified for most, but not all, communities. Those communities with access to natural gas for space heating, which were identified through discussions with Enstar staff, had Anchorage assigned as their representative community. Those communities identified as on the road system, but without access to natural gas, had Fairbanks assigned as their representative community (as it has no indigenous supply of natural gas). Remaining communities off the road system with their own electricity generation were assigned, depending on their location, either Northway Village or Port Graham as surrogates (the former represents activity on communities connected to the highway system and the latter represents a coastal community with marine activity).

The approach used to prepare emission estimates for these communities was to take the Anchorage and Fairbanks inventories, with the wildfire values netted out, and compute per capita emission estimates in 2002 and 2018 using the population estimates used to prepare each of these inventories. The year/pollutant-specific per capita values were then multiplied by the appropriate population estimates for each of the relevant communities.

A comparison of the results from this effort with the original estimates found a huge reduction in the estimated emissions for each borough. This represents the combination of lower population projections, and the use of more representative emission rates (lower levels of space heating, power generation, and fugitive dust emissions).

Given these revisions, the following sub-sections summarize sources that were represented within individual sectors, as well as provide an indication of which sectors were not included in the Regional Haze inventories and the rationale behind their exclusion.

4. Stationary Point Sources

Stationary point source emissions were based on the 2002 (Inv. 13, Version 4) and 2018 (Inv. 24, Preliminary Reasonable Further Progress, Version 2) Alaska point source inventories obtained from the WRAP.

These point source emissions were used "as is" without any adjustments. Latitude and longitude coordinates provided in the inventory datasets for each facility/source were used to spatially grid the point source emissions.

The Alaska point source inventories contained over 1,800 individual facility/device records encompassing over 130 unique source types as defined by the Source Classification Code (SCC).

a. Electric Generating Units

The point source inventory included emissions from electric generation units (EGU). Both external combustion boilers and internal combustion (IC) engines (turbines and reciprocating IC engines) were represented. Fuel types represented included subbituminous coal, distillate oil, and natural gas.

b. Non-EGU Point Sources

The remaining point sources included fuel combustion from external boilers and IC engines used in non-electricity generation industrial, commercial/institutional, and space heating applications. They also included major point source facility emissions from various industrial processes (e.g., chemical manufacturing, metal production, petroleum industry, oil and gas production), petroleum and solvent evaporation, and waste disposal.

5. Stationary Area Sources

Stationary area sources essentially included those stationary sources not directly represented as major facility point sources within the WRAP Point Source inventory, as well as other source categories for which emissions occur over areas rather than individual locations (e.g., fugitive dust).

Area source emissions were based on the area source components of the Big 3 and Representative Communities inventories. They included the following source types:

- Residential space heating (from fireplaces, wood stoves, fuel oil and natural gas);
- Fugitive dust;
- Surface coatings;
- Used oil combustion;
- Asphalt production and paving;
- Gasoline distribution; and
- Structural fires.

As noted earlier, wildfires were not included within the stationary area source inventories but were treated separately.

6. Non-Road Mobile Sources

Non-road mobile sources were generally developed within the Big 3 and Representative Communities studies using non-road equipment population and activity estimates compiled under those estimates combined with emission factors from EPA's NONROAD model. Source categories represented included the following:

- Off-road vehicles and equipment (loaders, excavators, tractors/dozers, forklifts, scrapers, graders, etc.);
- Lawn and garden tractors;
- Agricultural equipment;
- Pleasure craft;
- Snowmobiles and snowblowers;
- All terrain vehicles; and
- Off-road motorcycles.

Commercial marine vessels and aviation emissions (from both aircraft and ground support equipment) were also included but were treated separately for reporting and tabulation purposes within the Regional Haze inventory.

7. On-Road Mobile Sources

On-road mobile source emissions were based on combinations of on-road vehicle travel activity (i.e., vehicle miles traveled, VMT) combined with vehicle emission factors from EPA's MOBILE6.2 model. Emissions were calculated separately for each of the on-road vehicle types (passenger cars, light-duty trucks, heavy-duty trucks, buses, and motorcycles) defined in MOBILE.

For the Big 3 counties, county-wide travel activity was based on outputs from regional travel demand models or estimates based on traffic counts and road centerline miles as described in the Big 3 Inventory study report. For the remainder of the state, travel activity based on extrapolations from travel estimated within individual survey communities as documented in the Representative Communities study.

8. Biogenic Emissions Sources

Biogenic emissions (from trees and plant vegetation) were not included in these regional haze inventories because no biogenic inventories have been developed for Alaska. (Although biogenic emissions have been estimated for a number of states within the WRAP region, Alaska is not one of them.) Given its northerly location, preponderance of snow and ice cover, and short growing season, it would be problematic to extrapolate "lower 48" biogenic emission factors and activity to Alaska.

9. Geogenic Emissions Sources

Similarly, geogenic emissions (gas/oil seeps, wind erosion, and geothermal and volcanic activity) were also excluded due to lack of available data.

10. Wild and Other Fires

Fire emissions (except from structural fires) were based on the Phase III Fire Inventories obtained from the WRAP. The 2002 inventory came from the baseline 2000-2004 average fire inventory developed by the WRAP. The 2018 inventory was based on WRAP's 2018b projected inventory, which applied estimated emission reductions from the application of fire emission reduction techniques[52] to controllable emissions from prescribed and agricultural fires.

Fire sources included wildfires, wildland and range fires and prescribed burns. Latitude and longitude coordinates of the centroids of each individual fire contained within the WRAP datasets were used to spatially grid these fire emissions, as described later in Section III.K.5.E. Over 1,000 individual fires were represented in these inventories for Alaska.

11. International Transported Emissions

Internationally transported emissions were not included in these inventories. A number of studies such as Pollisar, et al. (2001)[53] have been conducted that have attributed atmospheric aerosols measured in Alaska to contributions from upwind regions as far away as portions of Asia and Russia based on back trajectory analysis and identification of unique chemical source signatures; however, robust emission estimates from these source areas are not available. Thus, no attempt was made to account for these international, long-range transported sources.

It is also noted that emission reductions developed to comply with the "glide path" requirements of the Regional Haze Rule that exclude contributions from other known sources, such as internationally transported sources will be directionally conservative (i.e., overstate the required reductions for in-state sources that were included).

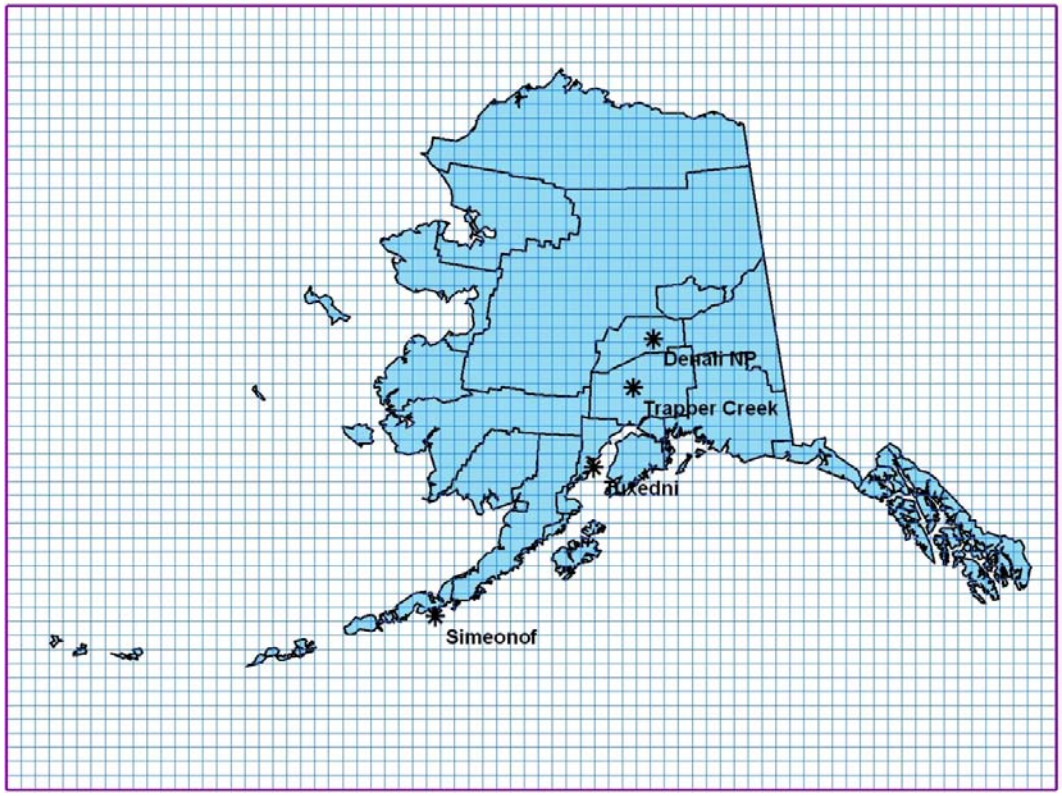
E. Inventory Processing and Gridding

1. Grid Domain

Once the inventory datasets were assembled and updated as described in Section III.K.5.D, the emissions data were spatially allocated into a modeling grid domain. The grid domain was based on one developed under an earlier WRAP study[54] for which a modeling protocol was developed and MM5-based meteorological datasets were prepared. This Alaska Grid domain is shown below in Figure III.K.5-2. It is defined on a polar stereographic projection, with central latitude 59°N and central longitude 101°W and a datum that assumes a perfectly spherical earth with a radius of 6370.997 km. This grid consists of 45 km square cells, with 75 cells (76 dot points) in the east-west direction and 56 cells (57 points) running north-south.

(This domain is smaller than the original domain developed under the earlier WRAP study. Once it was determined that only in-state emissions would be considered under for this effort, the original 45 km domain, which encompassed 108 east-west cells and 89 north-south cells and extended into Russia as well as western Canada, Washington and Oregon, was downsized to that depicted in Figure III.K.5-2.)

Figure III.K.5-2
Alaska Regional Haze Inventory 45 Km Grid Structure



2. Spatial Allocation

Emissions by source category were allocated into individual cells in the Alaska Grid domain using a more simplified approach than typically applied in gridded inventory development. Given the size of the grid cells (45 km square) as well as the size of populated areas within Alaska (and relative isolation from one area to the next), emissions for most of the source categories were geo-located into individual cells based on the city or town to which they were attributed. These spatial allocation methods are described below.

As described earlier, emissions from the following source sectors in all counties except Anchorage, Fairbanks, and Juneau were determined based largely on population-based extrapolations:

- Area sources (excluding fires);
- Non-road mobile sources (excluding commercial marine and aviation); and
- On-road sources.

Given the large size of the grid cells in relation to the size of all but the largest cities in the state (i.e., Anchorage, Fairbanks, and Juneau), emissions from these source categories were allocated to individual cities and towns based on populations and then allocated into a grid cell treating each city/town as a "point" source. U.S. census-based latitude and longitude coordinates for each of over 400 individual cities, towns, or tribal villages were used to assign emissions from the source sectors above to the appropriate grid cell.

For the three counties/boroughs containing the largest cities—Anchorage, Fairbanks, and Juneau—spatial emission allocations were more refined. A 2000 U.S. Census-based census block-level GIS shapefile layer was used to allocate county-wide emissions compiled for these three counties from the "Big-3" criteria pollutant inventories to specific grid cells. (Census "blocks" are the smallest and most spatially-resolved entity represented in the Census.) Cell allocations were based on the centroid location of each census block and were performed within ArcGIS.

Spatial allocation of emissions from commercial marine vessels, aviation, and fires was performed similarly, but not identically, to that described above for area, non-road, and on-road sources outside the Big-3 counties. First, commercial marine vessels emissions from the large ports represented in the Pechan study were allocated to the grid cell where each of the nine ports was located. Commercial marine vessels emissions for the roughly 160 small ports/harbors from the Representative Communities study were also "point" allocated to grid cells based on a single latitude/longitude coordinate set for each point. Second, aviation emissions (from aircraft and ground support equipment operation) were allocated using latitude/longitude coordinates for each of the over 1,200 airports, airfields, or airstrips obtained from the Federal Aviation Administration (FAA) or Alaska Department of Transportation and Public Facilities (DOT&PF) databases used to develop the emission estimates. Finally, fire emissions were also allocated as "point" sources based on the latitude/longitude coordinates assigned to each separate fire (wildfire, wildland fire or prescribed burn) in the Phase III WRAP Fire baseline database. (The largest individual fires represented in this database were still less than one-third the size of an individual grid cell, thus allocation accuracy using this "point" approach was not substantially affected.) Note that the commercial marine vessels, aviation, and fire source allocations were identical to those for area, non-road, and on-road sources except the allocations were based on directly represented activity and emissions for each source entity, rather than population-based allocations.

Finally, stationary point sources were allocated to grid cells in the "traditional" manner, based on the coordinates of each emitting device represented in the WRAP Point Source database for Alaska.

3. Gridded Emissions by Source Sector

Using the methods described above, emissions by county were allocated into cells within the modeling domain. To provide a better understanding of emission contributions impacting each Class I monitor, the data were gridded into separate layers by source sector as follows:

- Area (stationary area sources excluding fires);
- Non-Road (excluding commercial marine vessels and aviation);
- On-Road;
- Point;
- Commercial Marine Vessels;
- Aviation (aircraft and ground support equipment);
- Anthropogenic Fires (prescribed burns); and
- Natural Fires (wildfires, wildland fires and some prescribed burns).

Figures III.K.5-3 through III.K.5-10 present samples of these sector-specific gridded inventories, showing 2002 $PM_{2.5}$ emissions shaded density plots (in tons/year) for each individual sector in the order listed above. Note that the density intervals are not fixed, but increase geometrically. Thus, cells with medium or dark brown shading represent emission densities several orders of magnitude greater than the lightest shading. The geometric interval widths were necessary to keep the same set of intervals across all source sectors.

Although $PM_{2.5}$ area and non-road sources are more widespread throughout the state (with a larger number of shaded cells as seen in Figures III.K.5-3 and III.K.5-4), natural fires exhibit much greater emissions (and emission densities) than any other sector as seen in Figure III.K.5-10.

Similar plots to these were prepared for each of the other pollutants, for both the 2002 and 2018 inventories and provided to the WRAP's contractor ENVIRON as the basis for preparing Weighted Emission Potential (WEP) inventories described later in Section III.K.7.

Figure III.K.5-3
Baseline 2002 $PM_{2.5}$ Gridded Area Source Emissions (tons/year)

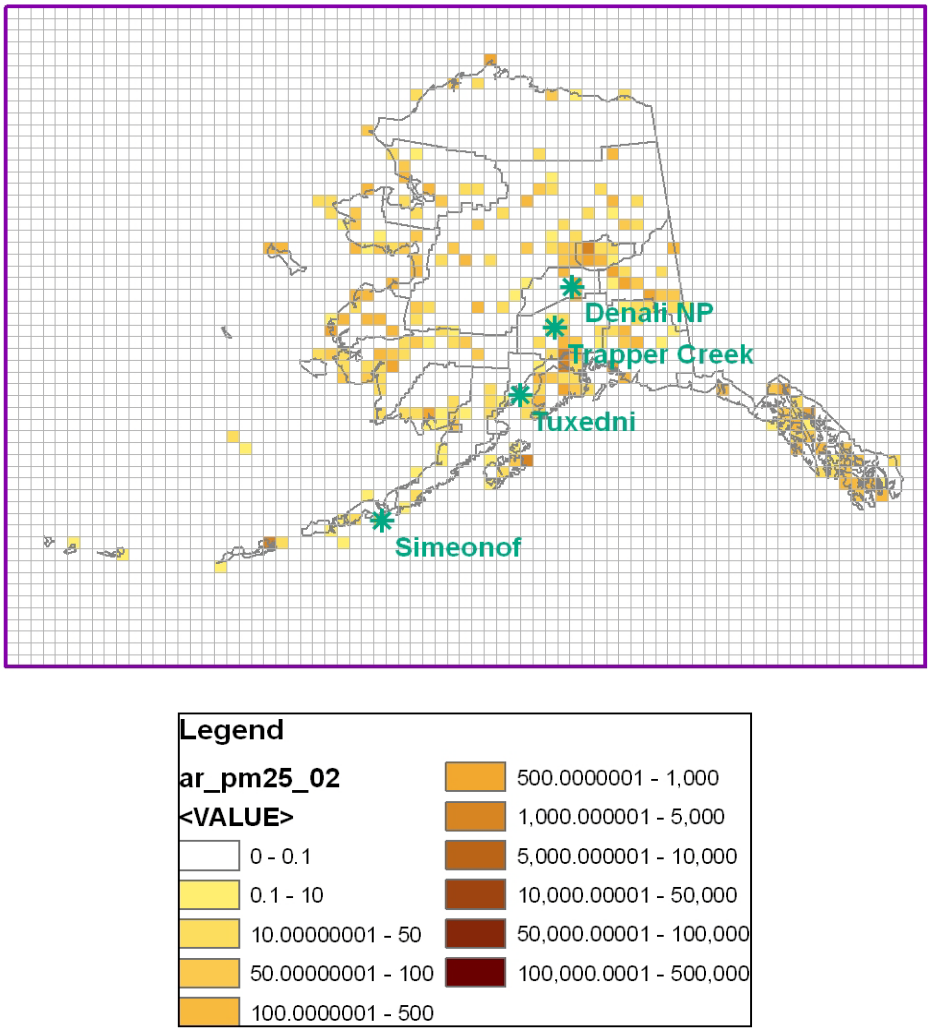
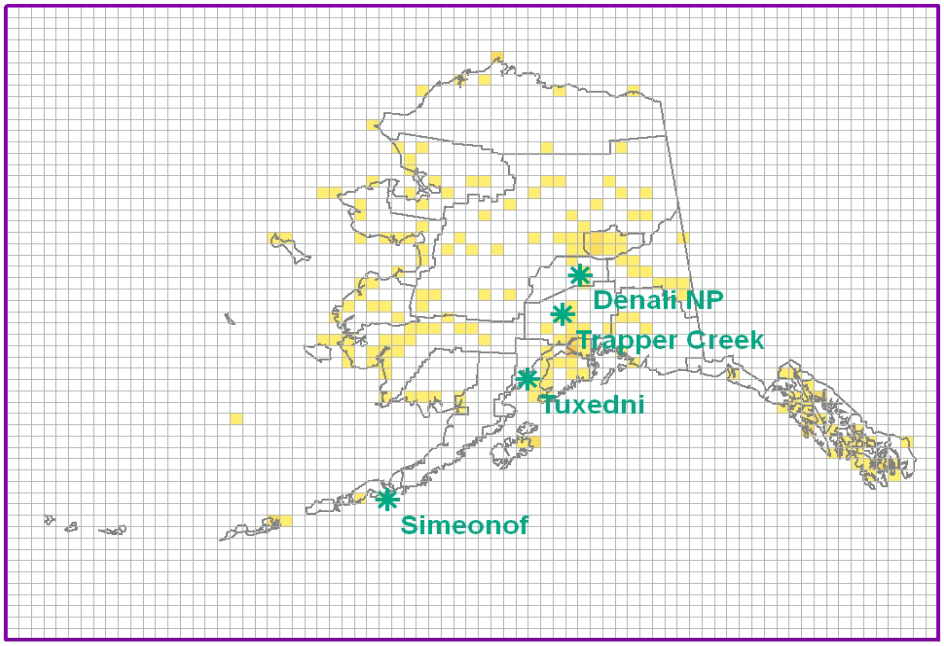


Figure III.K.5-4
Baseline 2002 $PM_{2.5}$ Gridded Non-Road Mobile Source (tons/year)



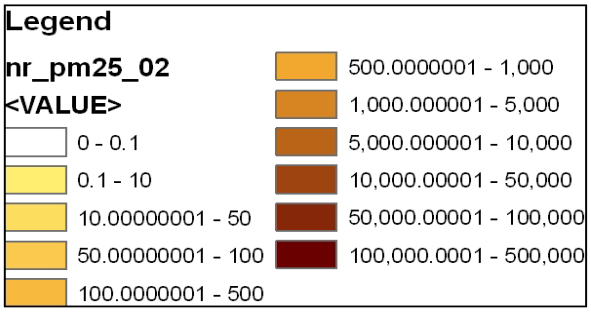


Figure III.K.5-5
Baseline 2002 $PM_{2.5}$ Gridded On-Road Mobile Source Emissions (tons/year)

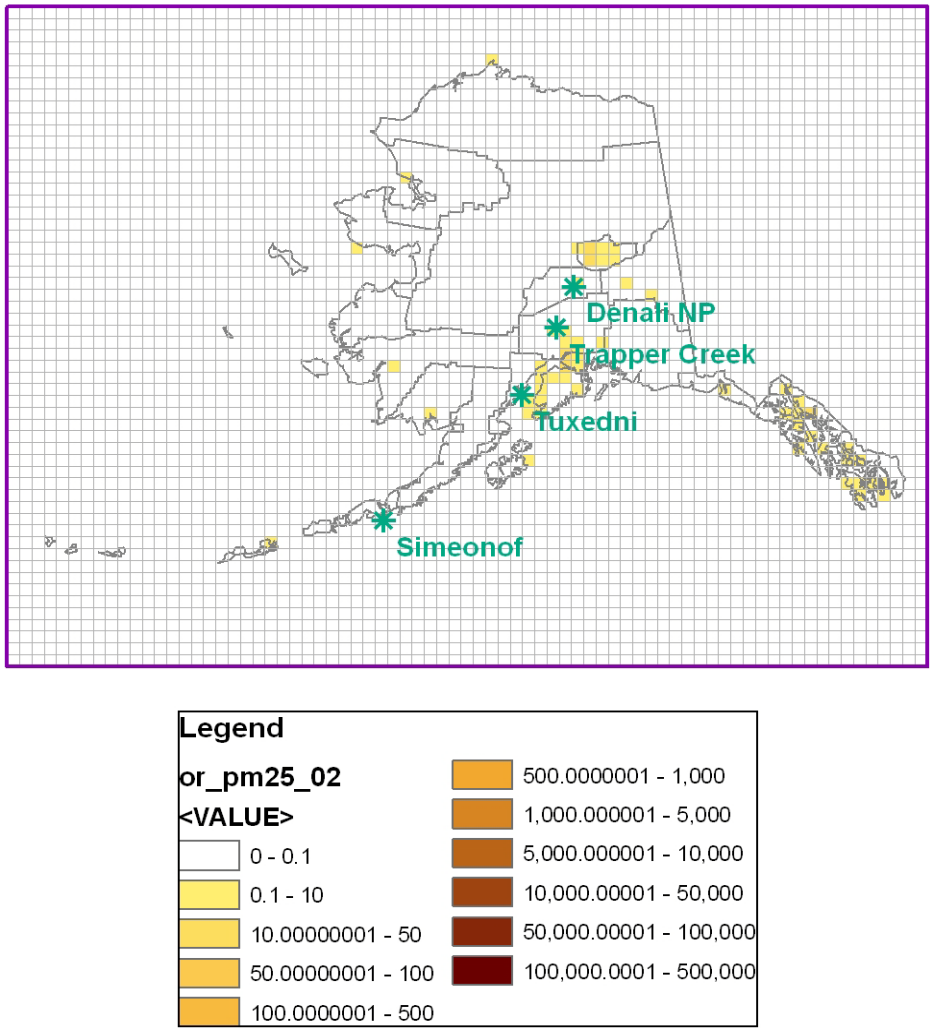
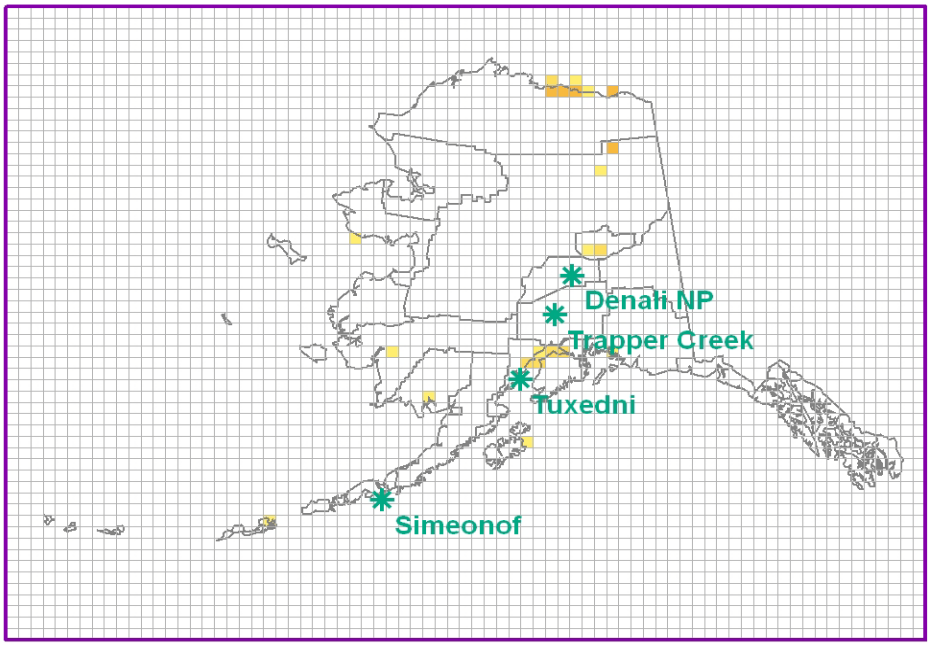


Figure III.K.5-6
Baseline 2002 $PM_{2.5}$ Gridded Point Source Emissions (tons/year)



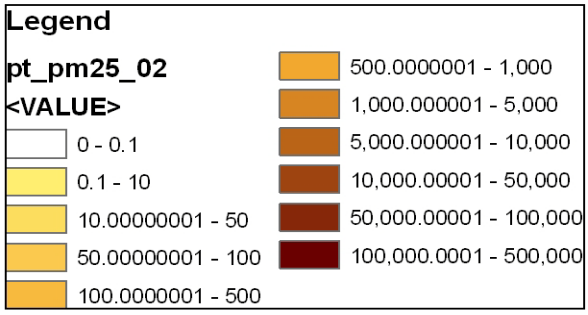


Figure III.K.5-7
Baseline 2002 $PM_{2.5}$ Gridded Commercial Marine Vessel Emissions (tons/year)

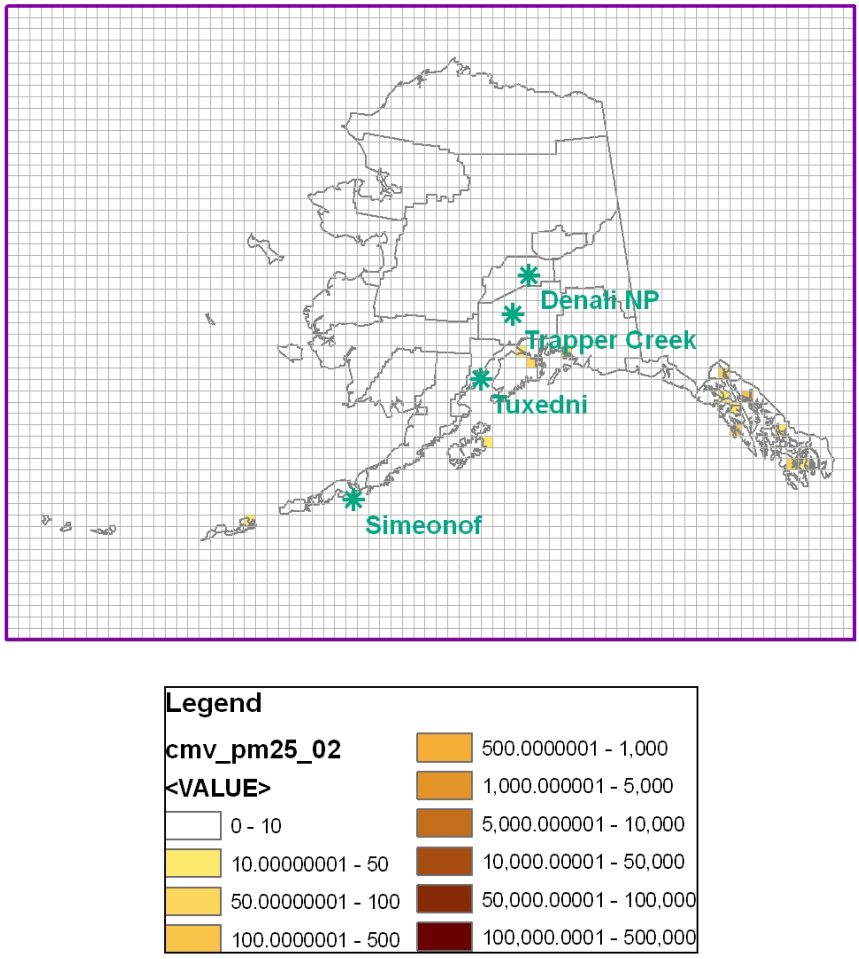
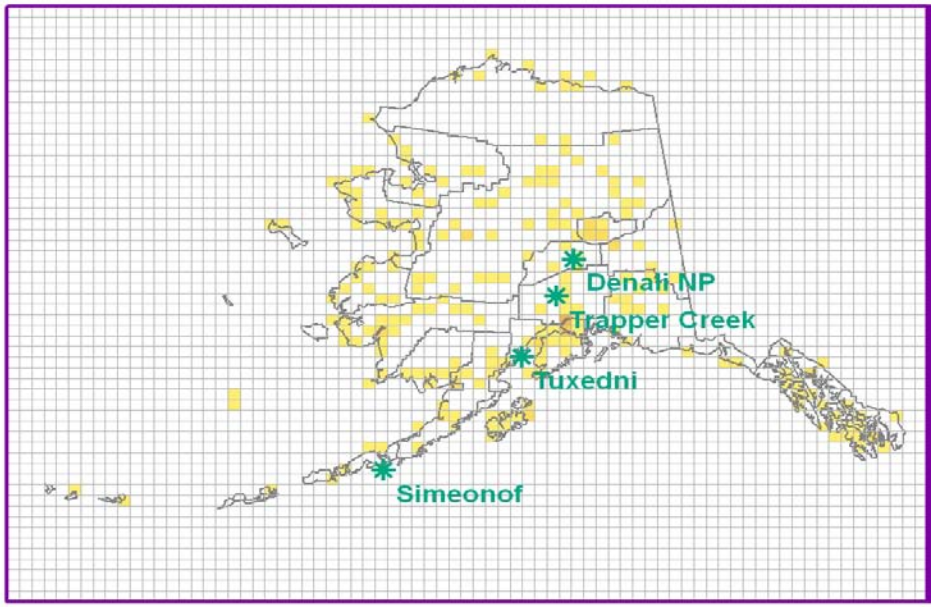


Figure III.K.5-8
Baseline 2002 $PM_{2.5}$ Gridded Aviation Source Emissions (tons/year)



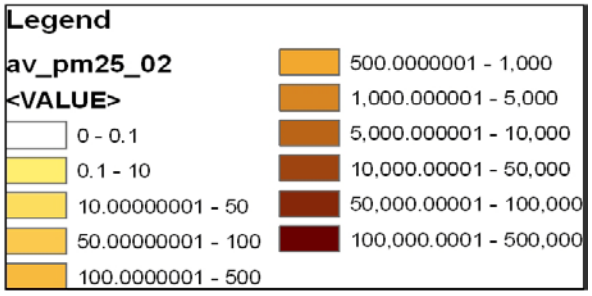
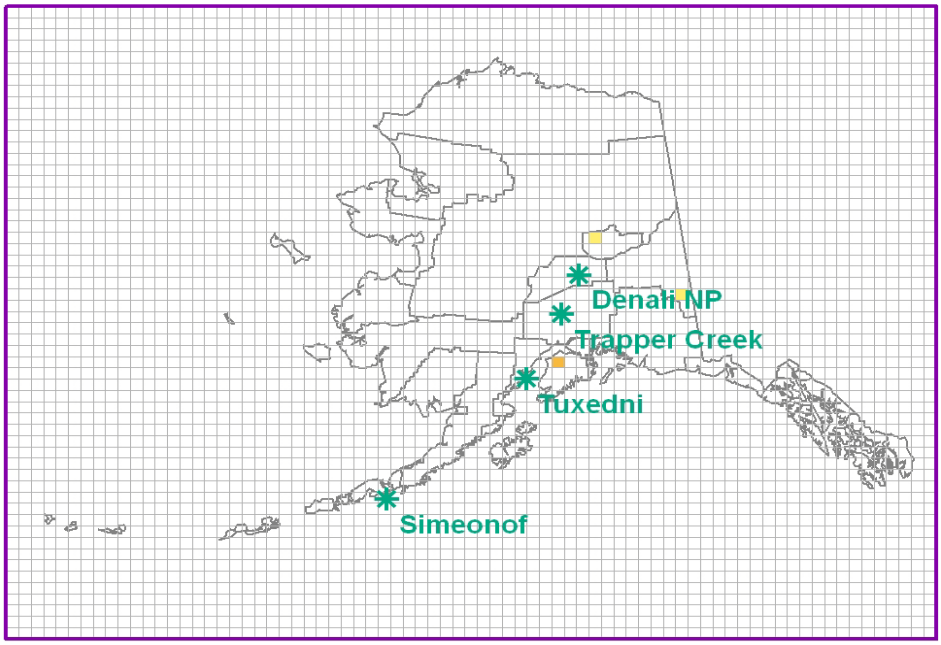


Figure III.K.5-9
Baseline 2002 $PM_{2.5}$ Gridded Anthropogenic Fire Emissions (tons/year)



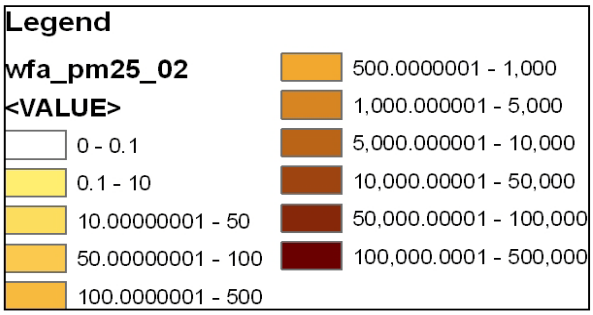
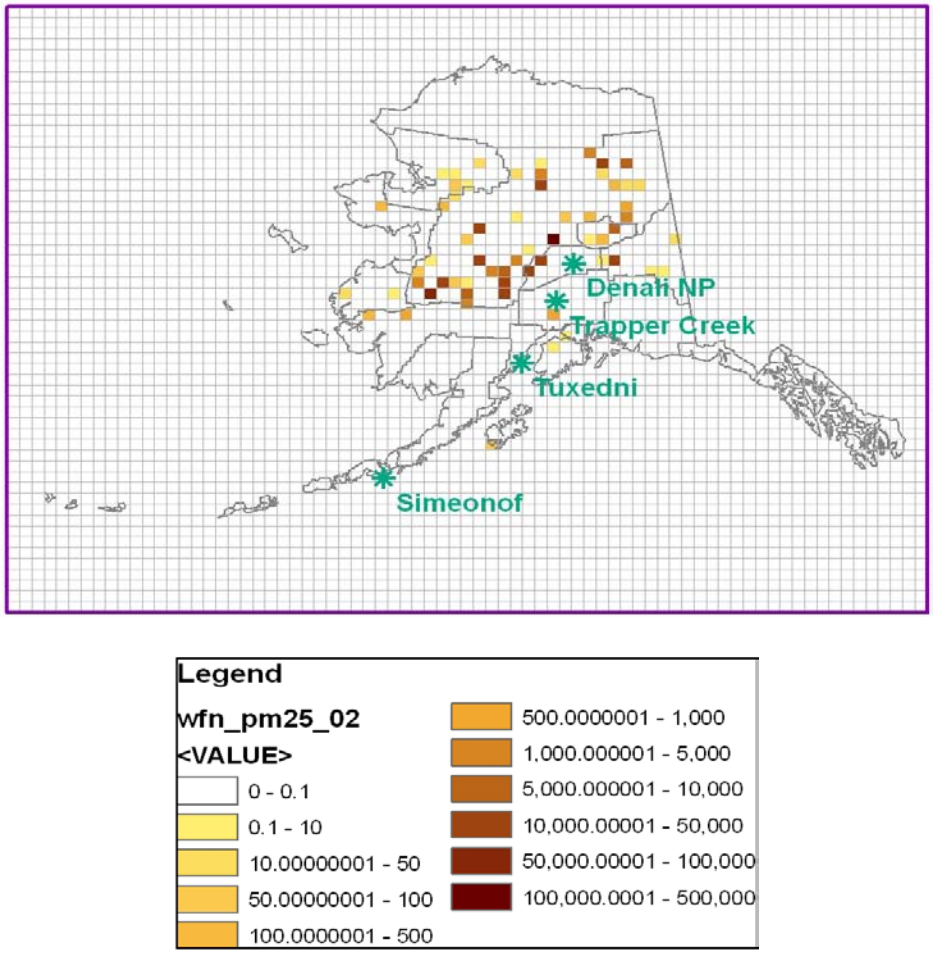


Figure III.K.5-10
Baseline 2002 $PM_{2.5}$ Gridded Natural Fire Emissions (tons/year)



F. Summary of Emission Inventories

In addition to the sector-specific 2002 and 2018 gridded emission inventory datasets described in the preceding sub-section, tabular emission summaries of total statewide and county-by-county emissions by source sector were also prepared.

Tables III.K.5-4 and III.K.5-5 show total statewide emissions (in tons/year) by source sector and pollutant for the calendar year 2002 and 2018 inventories, respectively. In addition to the totals across all source sectors, anthropogenic emission fractions (defined as all sectors except natural fires divided by total emissions) are also shown at the bottom of each table.

Table III.K.5-4
2002 Alaska Statewide Regional Haze Inventory Summary

Source Sector	Annual Emissions (tons/year)						
	HC	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SOx**	**NH_3**
Area, Excluding Wildfires	128,271	81,978	14,742	106,985	30,636	1,872	0
Non-Road	7,585	52,223	4,111	416	392	49	8
On-Road	7,173	80,400	7,077	204	158	324	307
Commercial Marine Vessels	356	2,880	11,258	663	643	4,979	5
Aviation (Aircraft & GSE)	1,566	21,440	3,265	699	667	335	6
Point	5,697	27,910	74,471	5,933	1,237	6,813	580
Wildfires, Anthropogenic	98	2,048	46	200	172	13	9
Wildfires, Natural	274,436	5,831,755	125,110	557,403	478,057	34,304	26,233
TOTAL - All Sources	**425,181**	**6,100,633**	**240,080**	**672,502**	**511,962**	**48,689**	**27,149**
Anthropogenic Fraction	**35.5%**	**4.4%**	**47.9%**	**17.1%**	**6.6%**	**29.5%**	**3.4%**

As Tables III.K.5-4 and III.K.5-5 clearly show, natural wildfires represent an overwhelming majority of emissions for all pollutants except NOx, for which they still contribute nearly half of all emissions statewide.

Table III.K.5-5
2018 Alaska Statewide Regional Haze Inventory Summary

Source Sector	Annual Emissions (tons/year)						
	HC	CO	NOx	PM_{10}	$PM_{2.5}$	SOx	NH_3
Area, Excluding Wildfires	137,696	88,030	15,683	116,629	33,329	2,068	0
Non-Road	7,766	65,900	3,332	337	313	47	9
On-Road	2,946	44,881	2,881	138	74	39	340
Commercial Marine Vessels	616	4,751	16,205	1,031	1,192	1,129	9
Aviation (Aircraft & GSE)	1,799	24,387	3,810	794	757	386	7
Point	6,612	24,406	65,230	1,783	358	8,587	1,106
Fires, Anthropogenic	53	1,100	26	107	93	7	5
Fires, Natural	274,436	5,831,755	125,110	557,403	478,057	34,304	26,233
TOTAL - All Sources	**431,925**	**6,085,210**	**232,277**	**678,223**	**514,173**	**46,568**	**27,709**
Anthropogenic Fraction	**36.5%**	**4.2%**	**46.1%**	**17.8%**	**7.0%**	**26.3%**	**5.3%**

Table III.K.5-6 summarizes the relative changes in statewide emissions by source sector and pollutant from 2002 to 2018. Emission increases (positive changes) are shown in black; emission decreases (negative changes) are shown in red.

Table III.K.5-6
Relative Change in Alaska Regional Haze Emissions from 2002 to 2018

Source Sector	Percentage Emissions Change 2002-2018						
	HC	CO	NOx	PM_{10}	$PM_{2.5}$	SOx	NH_3
Area, Excluding Wildfires	+7.3%	+7.4%	+6.4%	+9.0%	+8.8%	+10.4%	+20.7%
Non-Road	+2.4%	+26.2%	-18.9%	-19.1%	-20.2%	-4.2%	+14.9%
On-Road	-58.9%	-44.2%	-59.3%	-32.3%	-53.2%	-87.9%	+10.7%
Commercial Marine Vessels	+73.0%	+65.0%	+43.9%	+55.5%	+85.3%	-77.3%	+68.6%
Aviation (Aircraft & GSE)	+14.9%	+13.7%	+16.7%	+13.6%	+13.5%	+15.5%	+15.5%
Point	+16.1%	-12.6%	-12.4%	-69.9%	-71.1%	+26.0%	+90.8%
Fires, Anthropogenic	-45.5%	-46.3%	-43.8%	-46.2%	-46.0%	-43.8%	-45.8%
Fires, Natural	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%
TOTAL - All Sources	**+1.6%**	**-0.3%**	**-3.3%**	**+0.9%**	**+0.4%**	**-4.4%**	**+2.1%**

As seen in Table III.K.5-6, relative changes in pollutant emissions from 2002 to 2018 are very modest due to the large emissions contribution from natural fires, which were assumed to remain constant over this period. Even so, decreases in total NOx and SOx emissions of 3.3% and 4.4%

are projected on a statewide basis. However, these emission decreases are partially offset by lesser relative increases in statewide VOC, PM, and NH_3 emissions.

Appendix III.K.5 presents more detailed versions of these statewide emission summary tabulations, broken down county-by-county.

In addition to providing summaries of the 2002 and 2018 inventories, these tabulations were also used to independently cross-check the gridded emission allocations to ensure there were no lost or double-counted sources resulting from the spatial allocations. These cross-checks were performed by comparing the tabular summary data in Tables III.K.5-4 and III.K.5-5 to exported versions of the grid plots that were then totaled across all grid cells in the modeling domain. These cross-checks were performed by individual source sector.