COLORADO:
Denver Metro/North Front Range Final Nonattainment Area Area Designations for the 2015 Ozone National Ambient Air Quality Standards Technical Support Document (TSD) for Counties Remanded to EPA

1.0 Summary

This technical support document (TSD) describes the EPA's final action to designate all of Weld County, Colorado, as part of the Denver Metro/North Front Range (DM/NFR) nonattainment area for the 2015 Ozone National Ambient Air Quality Standard (NAAQS).

On October 1, 2015, the EPA promulgated revised primary and secondary ozone national ambient air quality standards (NAAQS (80 FR 6592, October 26, 2015)). In that action, the EPA strengthened both standards to a level of 0.070 parts per million (ppm), while retaining their indicators, averaging times, and forms. The EPA revised the ozone standards based on an integrated assessment of an extensive body of new scientific evidence, which substantially strengthens our knowledge regarding ozone-related health and welfare effects, the results of exposure and risk analyses, the advice of the Clean Air Scientific Advisory Committee and consideration of public comments.

Following promulgation of a new or revised NAAQS, the Clean Air Act (CAA) requires the EPA to determine if areas in the country meet the new standards. Accordingly, the EPA designated all areas of the country as to whether they met, or did not meet, the NAAQS. The EPA designated areas for the 2015 Ozone NAAQS in three rounds, resulting in 52 nonattainment areas. These are described below:

- Round 1- November 6, 2017: The EPA designated 2,646 counties, two separate tribal areas and five territories as Attainment/Unclassifiable. We also designated one Unclassifiable area.
- Round 2- April 30, 2018: The EPA designated 51 Nonattainment areas, one Unclassifiable area, and all remaining areas as Attainment/Unclassifiable, except for the eight counties in the San Antonio, TX area.
- Round 3- July 17, 2018: The EPA designated one county in the San Antonio area as Nonattainment and the other seven counties as Attainment/Unclassifiable.

Challenges to EPA's Designations

Multiple petitioners (several environmental and public health advocacy groups, three local government agencies, and the state of Illinois) filed six petitions for review challenging the EPA's 2015 ozone NAAQS designations promulgated on April 30, 2018. The District of Columbia Circuit Court consolidated the petitions into a single case, *Clean Wisconsin v. EPA* (No. 18-1203).

- Collectively, the petitioners challenged aspects of EPA's final designations associated with nine nonattainment areas, and involving 17 counties.
- Petitioners primarily argued that the EPA improperly designated counties (in whole or part) as attainment that should have been designated as nonattainment based on contributions to nearby counties with violating monitors.
- In its brief, the EPA requested voluntary remand of the final designation decisions for 10 counties associated with four nonattainment areas to further review those designations.

Court Decision

On July 10, 2020, the District of Columbia Circuit Court issued its decision on the April 30, 2018, designations. The Court granted the EPA's request for voluntary remand, as well as remanding a number of other areas to the Agency. In total, the Court remanded 16 counties in nine nonattainment areas back to the EPA. The Court did not vacate the existing designations but required the EPA to "issue revised designations as expeditiously as practicable."

The Court remanded EPA's designation of Weld County to the Agency. In its opinion, the Court stated that Weld County sources generate exceptionally high amounts of volatile organic compounds (VOC) and nitrogen oxides (NOx), and because northern Weld contributes a portion of those emissions the EPA must consider them. Furthermore, the Court concluded that the EPA presented conflicting characterizations of the topographical and meteorological data and relied on one "apparently mistaken" interpretation of those data to justify the nonattainment boundary in Weld County. In light of the Court decision, the EPA re-evaluated the existing technical record for Weld County using the data and information that was used for the initial April 2018 designations.

On May 26, 2021, EPA sent a 120-day letter to the Governor of Colorado with EPA's intended designation for the remanded Weld County. On June 14, 2021, EPA published a Notice of Availability in the Federal Register, providing EPA's intended designations for the remanded areas and starting a 30-day public comment period. The EPA received comments on its intended designation for the remanded Weld County and all comments received are posted in the docket for this action. EPA's responses to the comments received are also provided in the docket for this action.

Based on the EPA's updated technical analysis of the existing record as described in this TSD, the EPA is finalizing the 2018 air quality designation for Weld County to include the entire county within the nonattainment area. Table 1 shows the EPA's 2018 designation and the final 2018 designation. The EPA must designate an area nonattainment if it has an air quality monitor that is violating the standard or if it has sources of emissions that are contributing to a violation of the NAAQS in a nearby area.

Table 1. Recommended Nonattainment Counties and EPA's Final Designated Nonattainment Area for the 2015 Ozone NAAQS

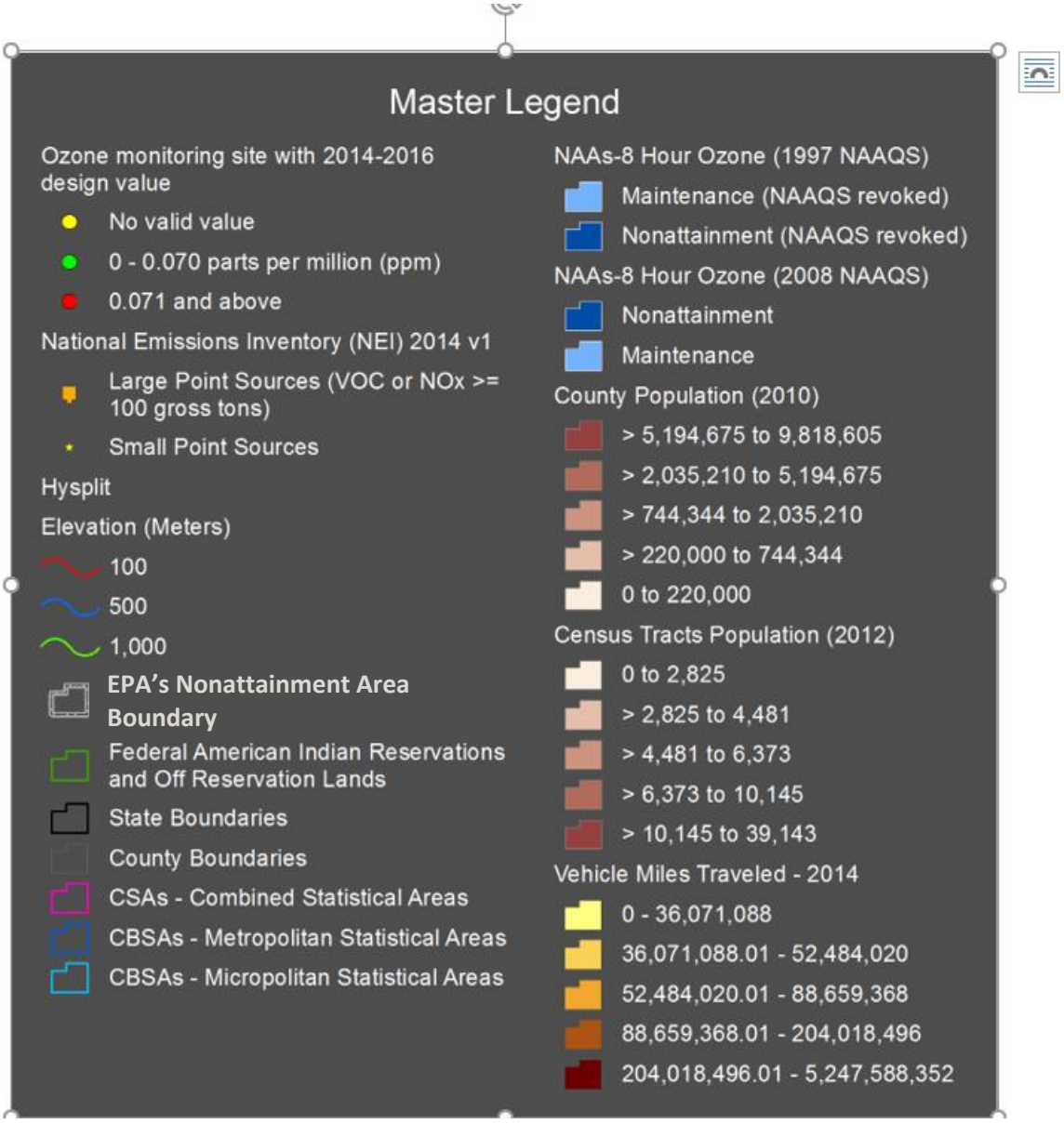
Denver Metro/North Front Range Nonattainment Area			
Recommended Nonattainment Counties September 15, 2016	**EPA's Intended Nonattainment Counties December 22, 2017**	**EPA's Final Nonattainment Counties April 30, 2018**	**EPA's Final Nonattainment Counties (Remand Response – November 2021)**
Boulder	Boulder	Boulder	Boulder
Denver	Denver	Denver	Denver
Arapahoe	Arapahoe	Arapahoe	Arapahoe
Jefferson	Jefferson	Jefferson	Jefferson
Adams	Adams	Adams	Adams
Douglas	Douglas	Douglas	Douglas
Broomfield	Broomfield	Broomfield	Broomfield
Weld (partial)	Weld (partial)	Weld (partial)	Weld
Larimer (partial)	Larimer (partial)	Larimer (partial)	Larimer (partial)

2.0 Nonattainment Area Analyses and Boundary Determination

The EPA re-evaluated the designations for Weld County considering the specific facts and circumstances of the area using data available at the time of the original designation in April 2018. In accordance with the CAA section 107(d), the EPA is designating as nonattainment the areas with the monitors that are violating the 2015 ozone NAAQS and nearby areas with emissions sources (i.e., stationary, mobile, and/or area sources) that contribute to the violations. As described in the EPA's Area Designations for the 2015 Ozone National Ambient Air Quality Standards memo[1] (hereafter referred to as the "ozone designations guidance"), after identifying each monitor indicating a violation of the ozone NAAQS in an area, the EPA analyzed those nearby areas with emissions potentially contributing to the violating area. In the ozone designations guidance, issued in February 2016, the EPA provided that using the Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)[2] as a starting point for the contribution analysis is a reasonable approach to ensure that the nearby areas most likely to contribute to a violating area are evaluated. The area-specific analyses may support nonattainment boundaries that are smaller or larger than the CBSA or CSA.

[1] The EPA's Ozone Designations Guidance and Data web page can be found at *https://www.epa.gov/ozone-designations/ozone-designations-guidance-and-data.*

[2] OMB adopted revised standards for defining Metropolitan and Micropolitan Statistical Areas on December 27, 2000 (65 FR 82229). These standards established the terms CSA and CBSA. In 2010, OMB further revised the standards for delineating Metropolitan and Micropolitan Statistical Areas (75 FR 37246, June 28, 2010). The statistical areas are delineated based on U.S. Census Bureau information. The EPA used the 2010 standards and the associated lists of CSAs and CBSAs issued in February 2013. These lists and their geographic components are provided at *https://www.census.gov/programs-surveys/metro-micro/geographies/reference-maps.html.*



Figures in the remainder of this document refer to the master legend above.

As noted above, the EPA completed initial area designations in three separate rounds. In accordance with the Court's decision, the EPA has re-evaluated the designations for Weld County consistent with the ozone designations guidance (and the EPA's past practices) regarding the scope of the area the EPA would analyze in determining nonattainment boundaries for the ozone NAAQS as outlined above. The Technical Analysis section below contains the EPA's re-analysis of the existing technical record for the DM/NFR nonattainment area with a focus on Weld County.

3.0 Technical Analysis for Denver Metro/North Front Range

This technical analysis identifies any monitors within the area of analysis that violate the 2015 ozone NAAQS. It also provides the EPA's evaluation of these areas (and the re-evaluation of Weld County) and any nearby areas to determine whether those nearby areas have emissions sources that potentially contribute to ambient ozone concentrations at the violating monitors in the area, based on the weight-of-evidence of the five factors recommended in the EPA's ozone designations guidance and any other relevant information. In developing this technical analysis, the EPA used only the technical data and information available at the time of the initial April 2018 designations.

The five factors recommended in the EPA's guidance are:

1. Air Quality Data (including the design value calculated for each Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitor;
2. Emissions and Emissions-Related Data (including locations of sources, population, amount of emissions, and urban growth patterns);
3. Meteorology (weather/transport patterns);
4. Geography/Topography (including mountain ranges or other physical features that may influence the fate and transport of emissions and ozone concentrations); and
5. Jurisdictional Boundaries (e.g., counties, air districts, existing nonattainment areas, areas of Indian country, Metropolitan Planning Organizations (MPOs)).

The analysis in Section 3.1 below incorporates the re-evaluation of Weld County, the remanded county, into this final TSD for the DM/NFR nonattainment area.

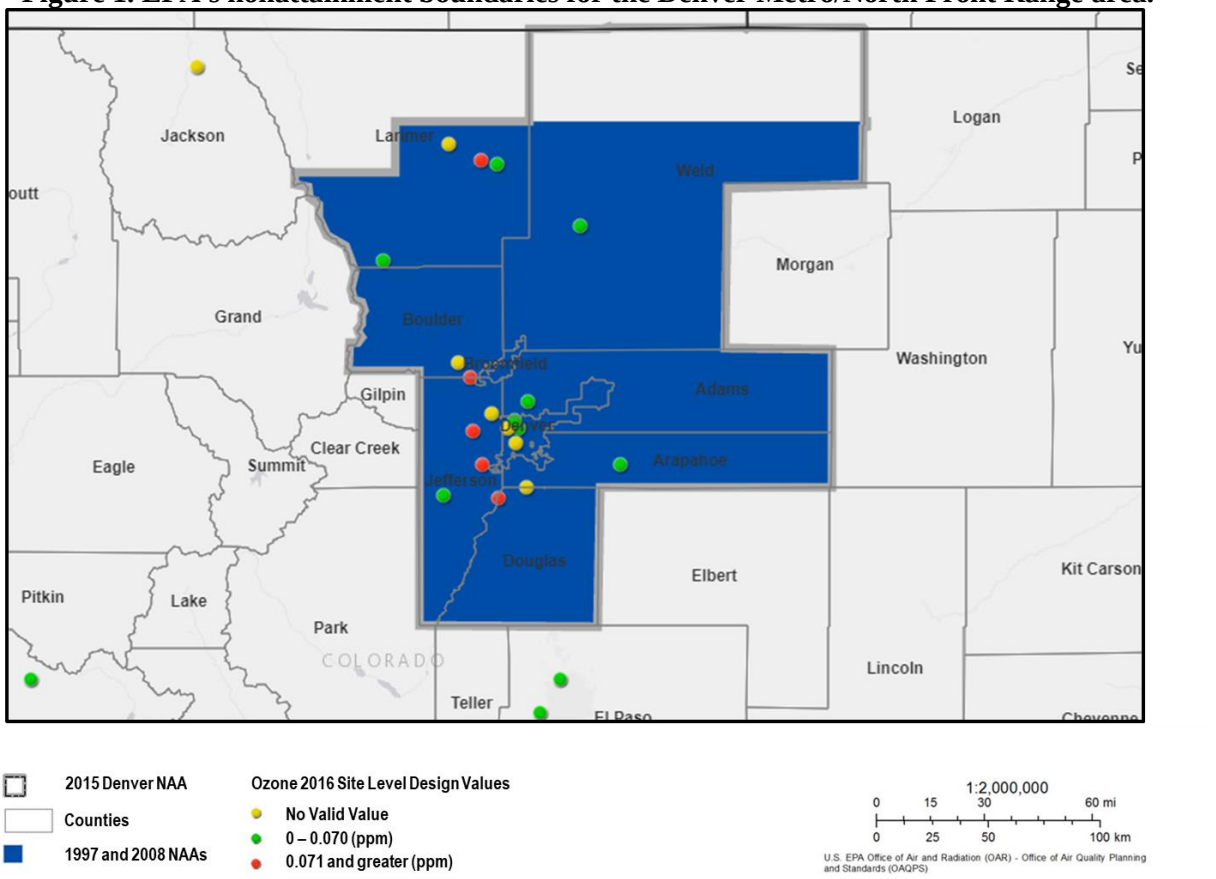
3.1 Technical analysis for Denver Metro/North Front Range Nonattainment Area

The Denver-Aurora CSA includes the Boulder CBSA, Denver-Aurora-Lakewood CBSA, and Greeley CBSA. The Fort Collins CBSA, which is comprised solely of Larimer County, is not a part of the Denver-Aurora CSA. For both the 1997 and the 2008 ozone NAAQS, part of the Larimer County was included as part of the designated Denver nonattainment area. The State has recommended part of Larimer county be included in the Denver nonattainment area for the 2015 ozone NAAQS. Therefore, the Fort Collins CBSA is included in the area of analysis. The counties included in the Boulder, Denver-Aurora-Lakewood, Greeley, and Fort Collins CBSAs, which comprise the area of analysis, are:

- Boulder
- Denver
- Arapahoe
- Jefferson
- Adams
- Douglas
- Broomfield
- Elbert
- Park
- Clear Creek
- Gilpin
- Weld
- Larimer

Figure 1 is a map of the EPA's final nonattainment boundary for the DM/NFR area. The map shows the location of the ambient air quality monitors, the design value levels at each monitor, the counties, and other jurisdictional boundaries including existing 1997 and 2008 ozone NAAQS nonattainment boundaries. For purposes of the 1997 and 2008 ozone NAAQS, the blue area was designated nonattainment. The boundary for the nonattainment area for both the 1997 and 2008 ozone NAAQS included the entire Counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson and the southern portion of Larimer and Weld Counties. The boundary for the 2015 ozone NAAQS is similar to the boundaries for the 1997 ozone NAAQS and the 2008 ozone NAAQS but includes the entirety of Weld County.

Figure 1. EPA's nonattainment boundaries for the Denver Metro/North Front Range area.



The EPA must designate as nonattainment any area that violates the NAAQS, and any nearby areas that contribute to these violations as determined by the five-factor analysis of the ozone designations guidance. Douglas, Jefferson, and Larimer Counties have monitors in violation of the 2015 ozone NAAQS, therefore all or portions of Douglas, Jefferson, and Larimer County are included in the nonattainment area. Based on the five-factor analysis that follows, the EPA determined that all of Douglas and Jefferson County and a portion of Larimer County should be included in the nonattainment area and that the counties of Adams, Arapahoe, Boulder, Broomfield, Denver and Weld County contribute to the violating area. The following sections describe the five-factor analysis. While the factors are presented individually, they are not independent of each other. The five-factor analysis process carefully considers the interconnections among the different factors and the dependence of each factor on one or more of the others, such as the interaction between emissions and meteorology for the area being evaluated.

Factor Assessment

Factor 1: Air Quality Data

The EPA considered 8-hour ozone design values in ppm for air quality monitors in the area of analysis based on data for the 2014-2016 period (i.e., the 2016 design value, or DV). This was the most recent 3-year period with fully-certified air quality data available for the April 2018 designation. The design value is the 3-year average of the annual 4th highest daily maximum 8-hour average ozone concentration.[3] The

[3] The specific methodology for calculating the ozone design values, including computational formulas and data completeness requirements, is described in 40 CFR part 50, appendix U.

2015 ozone NAAQS are met when the design value is 0.070 ppm or less. Only ozone measurement data collected in accordance with the quality assurance (QA) requirements using approved (FRM/FEM) monitors are used for NAAQS compliance determinations.[4] The EPA uses FRM/FEM measurement data residing in the EPA's Air Quality System (AQS) database to calculate the ozone design values. Individual exceedances of the 2015 ozone NAAQS that the EPA determines have been caused by an exceptional event that meets the administrative and technical criteria in the Exceptional Events Rule[5] are not included in these calculations. Whenever several monitors are located in a county (or designated nonattainment area), the design value for the county or area is determined by the monitor with the highest valid design value. The presence of one or more violating monitors (i.e., monitors with design values greater than 0.070 ppm) in a county or other geographic area forms the basis for designating that county or area as nonattainment. The remaining four factors are then used as the technical basis for determining the spatial extent of the designated nonattainment area surrounding the violating monitor(s) based on a consideration of what nearby areas are contributing to a violation of the NAAQS.

The EPA identified monitors where the most recent design values violate the NAAQS and examined historical ozone air quality measurement data (including previous design values) to understand the nature of the ozone ambient air quality problem in the area. Eligible monitors for providing design value data generally include State and Local Air Monitoring Stations (SLAMS) that are operated in accordance with 40 CFR part 58, appendix A, C, D and E and operating with an FRM or FEM monitor. These requirements must be met in order to be acceptable for comparison to the 2015 ozone NAAQS for designation purposes. All data from Special Purpose Monitors (SPMs) using an FRM or FEM are eligible for comparison to the NAAQS, subject to the requirements given in the March 28, 2016 Revision to Ambient Monitoring Quality Assurance and Other Requirements Rule (81 FR 17248). The 2014-2016 design values for counties in the area of analysis are shown in Table 2.

[4] The QA requirements for ozone monitoring data are specified in 40 CFR part 58, appendix A. The performance test requirements for candidate FEMs are provided in 40 CFR part 53, subpart B.

[5] EPA finalized the rule on the Treatment of Data Influenced by Exceptional Events (81 FR 68513) and the guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events in September of 2016. For more information, see *https://www.epa.gov/air-quality-analysis/exceptional-events-rule-and-guidance*.

Table 2. Air Quality Data (all values in ppm)

County, State	State Recommended Nonattainment?	AQS Site ID (Site Name)	2014-2016 DV	2014 4th highest daily max value	2015 4th highest daily max value	2016 4th highest daily max value
Adams, CO	Yes	08-001-3001 (Welby)	**0.067**	0.067	0.069	0.066
Arapahoe, CO	Yes	08-005-0002 (Highland Res.)	N/A	N/A	0.062	0.072
		08-005-0006 (Aurora East)	**0.067**	0.067	0.068	0.066
Boulder, CO	Yes	08-013-0011 (S Boulder)	N/A	0.070	0.074	N/A
Broomfield, CO	Yes	No monitor	N/A			
Clear Creek, CO	No	No monitor	N/A			
Denver, CO	Yes	08-031-0002 (CAMP)	0.066	0.061	0.067	0.070
		08-031-0026 (La Casa)	**0.068**	0.066	0.071	0.069
Douglas, CO	Yes	08-035-0004 (Chatfield)	**0.077**	0.074	0.081	0.078
Elbert, CO	No	No monitor	N/A			
Gilpin, CO	No	No monitor	N/A			
Jefferson, CO	Yes	08-059-0005 (Welch)	0.072	0.066	0.075	0.075
		08-059-0006 (Rocky Flats)	0.077	0.077	0.077	0.079
		08-059-0011 (NREL)	**0.080**	0.076	0.081	0.083
		08-059-0013 (Aspen Park)	0.070	0.067	0.070	0.073
Larimer, CO	Yes (partial)	08-069-0007 (RMNP)	0.069	0.069	0.069	0.069
		08-069-0011 (Ft. Collins W.)	**0.075**	0.074	0.075	0.076
		08-069-1004 (Ft. Collins)	0.070	0.072	0.069	0.070
Park, CO	No	No Monitor	N/A			
Weld, CO	Yes (partial)	08-123-0009 (Greeley Twr.)	**0.070**	0.070	0.073	0.067

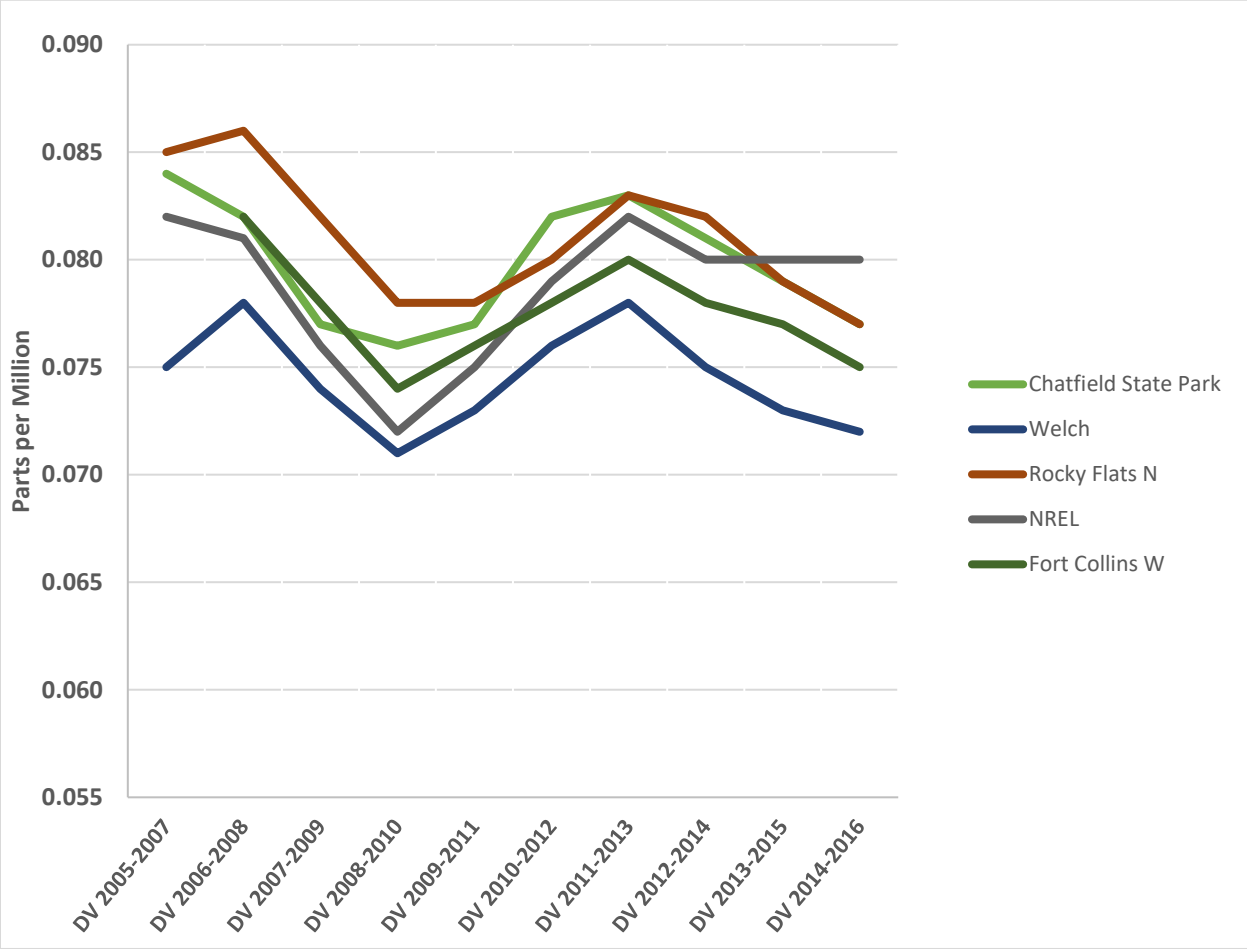
- The highest design value in each county is indicated in bold type.
- N/A means that the monitor did not meet the completeness criteria described in 40 CFR, part 50, Appendix U, or no data exists for the county.

Douglas, Jefferson, and Larimer Counties show a violation of the 2015 ozone NAAQS. A county (or partial county) must also be designated nonattainment if it contributes to a violation in a nearby area.

Figure 1, above, identifies the DM/NFR nonattainment area and the violating monitors in the area of analysis. Table 2, above, identifies the design values for all monitors in the area of analysis and Figure 2,

below, shows the historical trend of design values for the violating monitors. As indicated on the map, there are five violating monitors that are located in Chatfield State Park in Douglas County (08-035-0004); near the town of Morrison (Welch, 08-059-0005), City of Golden (National Renewable Energy Laboratory (NREL), 08-059-0011), and Rocky Flats National Wildlife Refuge (08-059-0006) in Jefferson County; and City of Fort Collins in Larimer County (Ft. Collins W., 08-069-0011). There is one monitor east and one southwest of the violating monitor in Larimer County that are attaining. There is also one monitor west of the violating monitors in Jefferson County that is attaining. The remainder of the monitors in Adams, Arapahoe, Boulder, Denver, and Weld Counties are attaining. As shown in Figure 2, the monitor at NREL has the highest 2016 DV, followed by monitors at Rocky Flats North, Chatfield State Park, Fort Collins West, and Welch.

Figure 2. Three-year design values for violating monitors (2007-2016).



Factor 2: Emissions and Emissions-Related Data

The EPA evaluated ozone precursor emissions of NOx and VOC and other emissions-related data that provide information on areas contributing to violating monitors.

Emissions Data

The EPA reviewed data from the 2014 National Emissions Inventory (NEI) v1. For each county in the area of analysis, the EPA examined the magnitude of large sources and small point sources and the

magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires. Emissions levels from sources in a nearby area indicate the potential for the area to contribute to violating monitors.

Table 3 provides a county-level emissions summary of NOx and VOC given in tons per year (tpy) emissions for the area of analysis considered for inclusion in the DM/NFR nonattainment area.

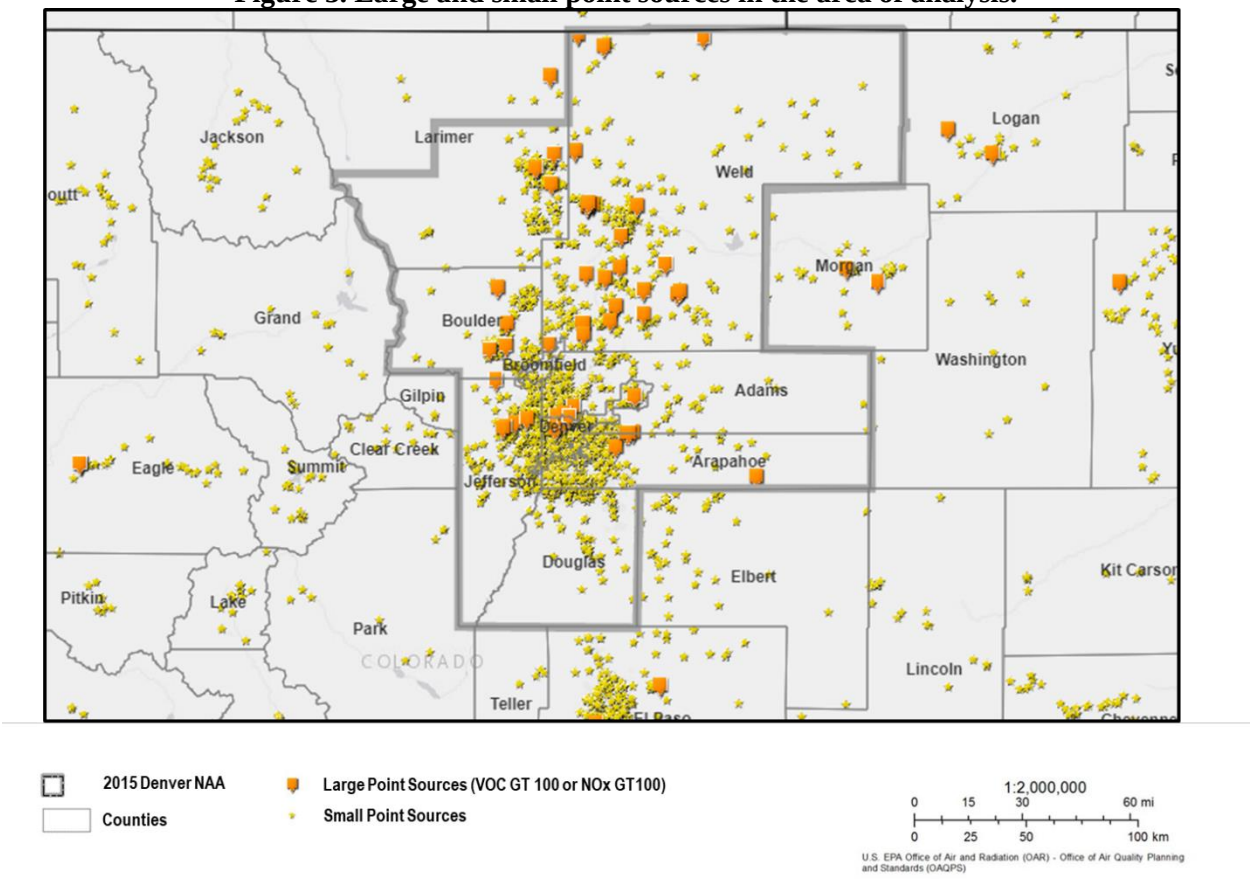
Table 3. Total county-level NOx and VOC 2014 emissions 2014 NEI v1.

County	State Recommended Nonattainment?	Total NOx (tpy)	Total VOC (tpy)
Weld	Yes (partial)*	31,318	102,046
Adams	Yes	17,651	12,927
Denver	Yes	15,408	12,746
Jefferson	Yes	10,737	11,445
Arapahoe	Yes	10,191	12,726
Boulder	Yes	8,441	6,484
Larimer	Yes (partial)*	7,938	8,307
Douglas	Yes	6,879	5,755
Clear Creek	No	1,654	550
Broomfield	Yes	1,297	1,326
Elbert	No	989	737
Park	No	577	1,325
Gilpin	No	396	196
	Area wide:	113,475	176,570

* For state recommended partial counties, the emissions shown are for the entire county.

In addition to reviewing county-wide NOx and VOC emissions in the area of analysis, the EPA also reviewed emissions from large and small point sources. Large point sources are those that emit 100 tpy of NOx or VOC emissions and small point sources are those that report less than 100 tpy of NOx or VOC emissions. The location of these sources, together with the other factors, can help inform nonattainment boundaries. The locations of these point sources are shown in Figure 3 below along with the DM/NFR nonattainment boundary. One item to note from this figure is that the northern portion of Larimer County only contains one of the four large point sources and only five (3%) of the roughly 158 small point sources in the county.

Figure 3. Large and small point sources in the area of analysis.



Weld County has the highest NOx emissions in the area of analysis, followed by Adams and Denver with approximately 56 and 49 percent, respectively, of the level of emissions in Weld. Jefferson and Arapahoe each have about 33 percent the level of NOx emissions as Weld County. Boulder, Larimer and Douglas Counties each have in the range of 22 to 27 percent the level of NOx emissions as Weld County. The remaining five counties each have about 5 percent or less than the NOx emissions from Weld County. Weld County also has the highest level of VOC emissions. The counties with the next highest level of emissions, Adams, Denver, Arapahoe and Jefferson each have emissions of approximately 11 to 13 percent of those in Weld. Boulder, Larimer and Douglas Counties have approximately 6 to 8 percent of the VOC emissions from Weld County. The remaining counties all have roughly 1 percent or less VOC emissions from Weld County.

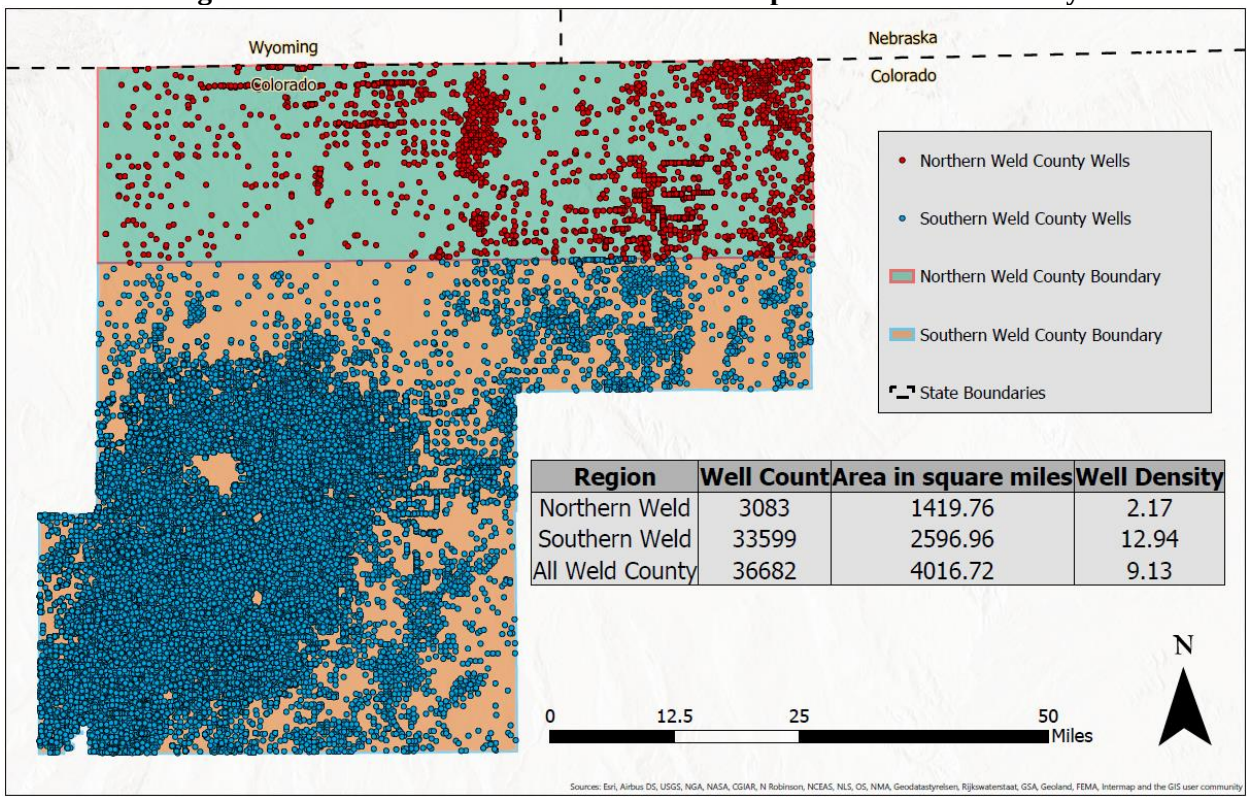
The State did not recommend the northern portions of Weld and Larimer counties for inclusion in the nonattainment area. The State of Colorado Technical Support Document for Recommended 8-Hour Ozone Designations [6] (hereafter referred to as the "Colorado 2016 TSD") provided an estimate of the partial county emissions from the northern portions of Larimer and Weld counties in their TSD, however they used two separate and unique inventories to make the comparison. Colorado estimated the portion of the counties' northern emissions by taking the difference between the whole county emissions inventory[7] derived from the EPA's NEI 2011 v2 and the partial county emissions inventory derived from the 2008

[6] State of Colorado Technical Support Document for Recommended 8-Hour Ozone Designations, Colorado Air Quality Control Commission, Adopted September 15, 2016. See *https://www.epa.gov/ozone-designations/ozone-designations-2015-standards-colorado-state-recommendations-and-epa-response*.
[7] See Table 1-2 of the Colorado 2016 TSD.

Ozone Moderate Attainment State Implementation Plan. This approach is problematic because there are differences between the two inventories. For instance, emissions in each category listed in Table 1-2 of Colorado's 2016 TSD will differ between the 2011 NEI and the inventory developed for ozone attainment planning. In addition, the emissions used in the analysis submitted by Colorado may differ from the 2014 NEI emissions relied upon by the EPA. Therefore, the EPA does not have an accurate understanding of actual emissions from the northern portion of Weld County.

The Colorado 2016 TSD displays the 2011 emissions data for NOx and VOC emissions for 16 source categories for the counties in the area of analysis.[8] This table indicates that that the oil and gas source category accounts for the highest ozone precursor emissions of all source categories in Weld County; 41% of the Weld County controllable NOx and 78% of the controllable VOC come from oil and gas. Figure 4 shows that the majority of the wells in Weld County are contained within the state's recommended boundary, but it also shows that over 3,000 wells (or about 8% of the wells) are located in the northern portion of Weld County.[9] Given the large amount of NOx and VOC emissions from Weld County (Table 3), the fact that oil and gas wells account for the highest ozone precursor emissions out of all of the source categories in Weld County, and that approximately 8% (i.e., 3,083 of 36,682) of the county's wells are present in the northern portion of the county, it is reasonable to conclude there is a large amount of NOx and VOC emissions from oil and gas emissions originating in the northern portion of Weld County compared with other counties in the area of analysis.

Figure 4. Well counts in northern and southern portions of Weld County



Region	Well Count	Area in square miles	Well Density
Northern Weld	3083	1419.76	2.17
Southern Weld	33599	2596.96	12.94
All Weld County	36682	4016.72	9.13

[8] See Table 1-2 of Colorado's 2016 TSD.
[9] The figure and well counts include those wells that were active as well as plugged and abandoned at the time of analysis. 2017 COGC oil and gas well data shapefiles can be found in the docket.

Population density and degree of urbanization

In this part of the factor analysis, the EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. These include emissions of NOx and VOC from on-road and non-road vehicles and engines, consumer products, residential fuel combustion, and consumer services. Areas of dense population or commercial development are an indicator of area source and mobile source NOx and VOC emissions that may contribute to violations of the NAAQS. Table 4 shows the population, population density, and population growth information for each county in the area of analysis.

Table 4. Population and Growth.

County	State Recommended Nonattainment?	2010 Population	2015 Population	2015 Population Density (per sq. mi.)	Absolute change in population (2010-2015)	Population % change (2010-2015)
Denver, CO	Yes	600,158	682,545	4461	82,387	14
Arapahoe, CO	Yes	572,003	631,096	791	59,093	10
Jefferson, CO	Yes	534,543	565,524	740	30,981	6
Adams, CO	Yes	441,603	491,337	421	49,734	11
Larimer, CO	Yes (partial)*	299,630	333,577	128	33,947	11
Douglas, CO	Yes	285,465	322,387	384	36,922	13
Boulder, CO	Yes	294,567	319,372	440	24,805	8
Weld, CO	Yes (partial)*	252,825	285,174	72	32,349	13
Broomfield, CO	Yes	55,889	65,065	1970	9,176	16
Elbert, CO	No	23,086	24,735	13	1,649	7
Park, CO	No	16,206	16,510	8	304	2
Clear Creek, CO	No	9,088	9,303	24	215	2
Gilpin, CO	No	5,441	5,828	39	387	7
	Area wide:	3,390,504	3,752,453	240	361,949	11

* For state recommended partial counties, the emissions shown are for the entire county.
Source: U.S. Census Bureau population estimates for 2010 and 2015. *www.census.gov/data.html*

Table 4 indicates Denver County has the greatest population, population density, absolute change in population, and population percent change from 2010-2015. Arapahoe County has the next greatest population (92% of Denver County), followed by Jefferson (82% of Denver County), and Adams (71% of Denver County). Larimer, Douglas, Boulder and Weld all have populations that are approximately 48% - 42% of Denver County and they had population growth ranging from 8 to 13%. Boulder and Douglas are

more densely populated than either Larimer or Weld. The remaining five counties (Broomfield, Elbert, Park, Clear Creek and Gilpin) all have relatively low populations (less than 60,000). However, Broomfield County is both densely populated for counties in the area of analysis and had high growth. Elbert, Park, Clear Creek and Gilpin are the least densely populated and had the lowest growth for counties in the area of analysis.

The State provided data regarding the northern portions of Larimer and Weld Counties, which it did not recommend for inclusion in the designated nonattainment area. The data demonstrate that the northern portion of Larimer County has 16,679 people (2% of Denver County), while the northern portion of Weld County has 2,852 people (0.4% of Denver County). The Colorado 2016 TSD also provided Figure 5 below which shows the population density by census tract and the degree of urbanization for NE Colorado, SE Wyoming and SW Nebraska based on the 2010 US Census. The state-recommended nonattainment area is highlighted in black and some peripheral counties are labeled.

Figure 5. Population density & degree of urbanization of the NE Colorado region and the state-recommended nonattainment area.

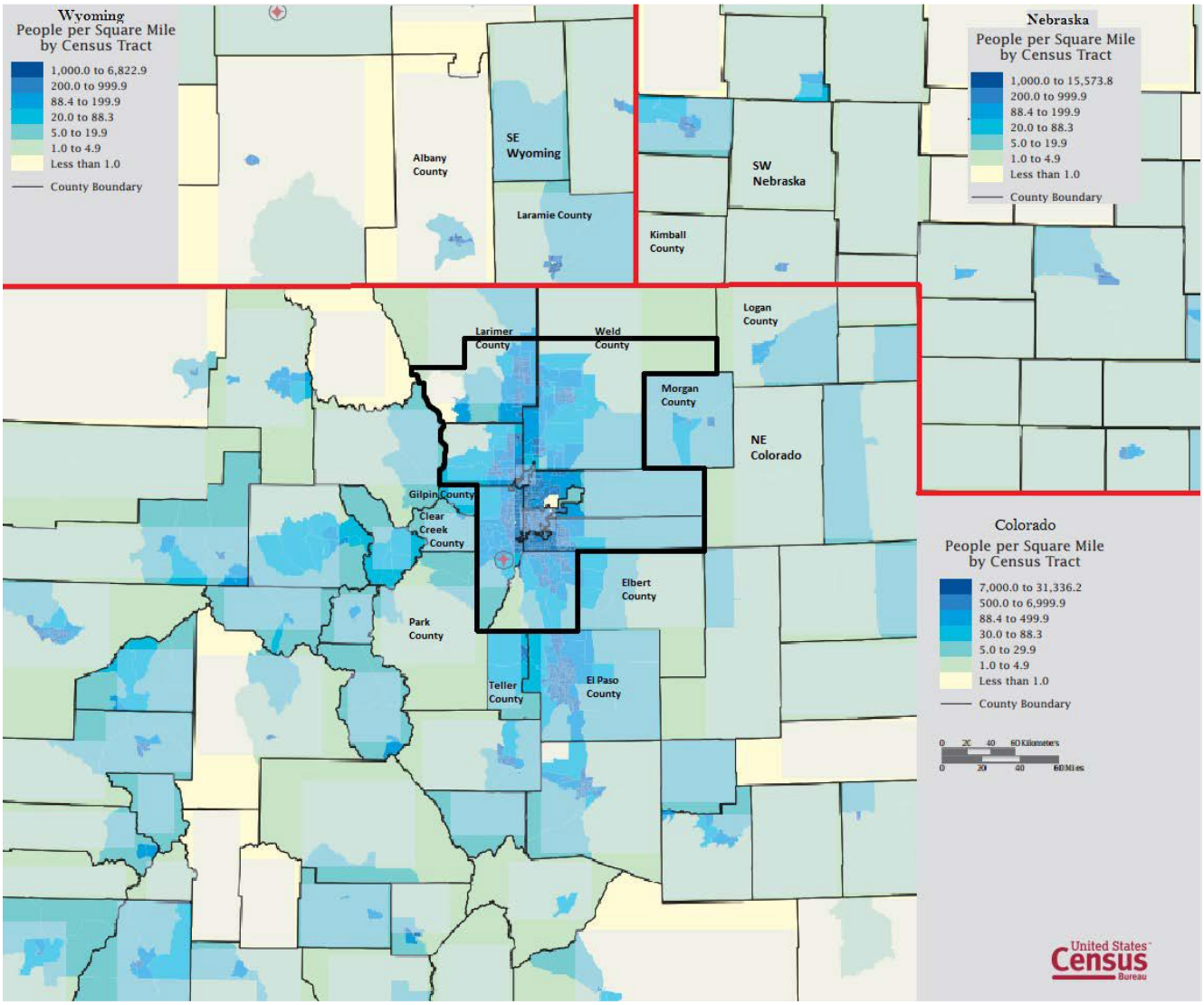


Figure 6. County-level population.

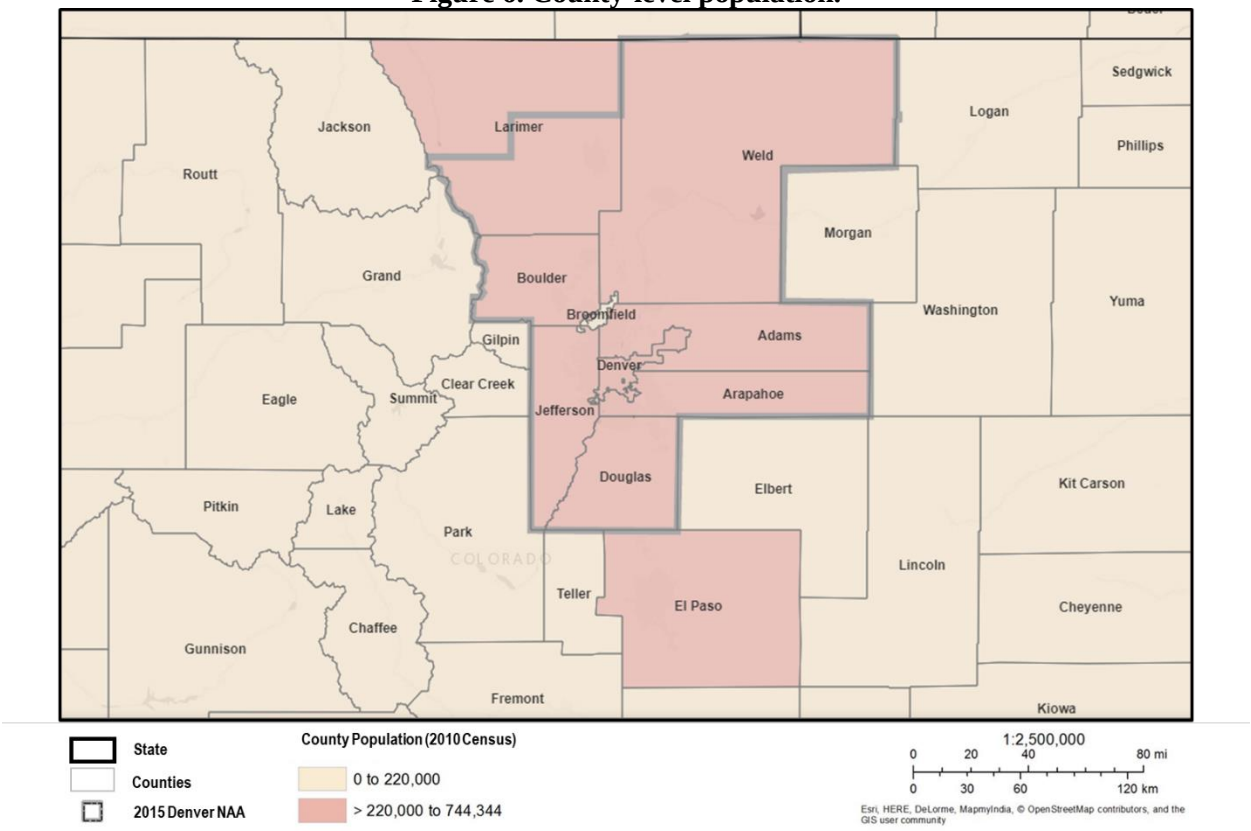


Figure 6 illustrates that urbanization rapidly diminishes beyond the central portion of the nonattainment boundary, but since this is county-level data, it does not illustrate the specific location of the population within each county.

Traffic and Vehicle Miles Travelled (VMT)

The EPA evaluated the commuting patterns of residents, as well as the total vehicle miles traveled (VMT) for each county in the area of analysis. In combination with the population/population density data and the location of main transportation arteries, this information helps identify the probable location of non-point source emissions. A county with high VMT and/or a high number of commuters is generally an integral part of an urban area and high VMT and/or high number of commuters indicates the presence of motor vehicle emissions that may contribute to violations of the NAAQS. Rapid population or VMT growth in a county on the urban perimeter may signify increasing integration with the core urban area, and thus could indicate that the associated area source and mobile source emissions may be appropriate to include in the nonattainment area. In addition to VMT, the EPA evaluated worker data collected by the U.S. Census Bureau[10] for the counties in the area of analysis. Table 5 shows the traffic and commuting pattern data, including total VMT for each county in the area of analysis, number of residents who work in each county, number of residents that work in counties with violating monitor(s), and the percent of residents working in counties with violating monitor(s). The values in Table 5 are based on 2014 data. Table 5 indicates that Denver County has the greatest total VMT (5,682 million miles). Denver is the largest metropolitan area in the area of analysis but does not have a monitor that is violating the 2015 ozone NAAQS; thus, although it has the greatest number of county residents who work (299,489 people)

[10] The worker data can be accessed at: *http://onthemap.ces.census.gov/*.

the percent that commute to an area with a violating monitor is relatively small (16%). The three counties with the violating monitors, Jefferson, Douglas, and Larimer, have the highest percentage of commuters commuting within or to a county with a violating monitor. Respectively, they rank 2nd, 6th and 7th in number of people who work. Jefferson County also ranks second for total VMT (4,704 million miles), followed closely by Adams and Arapahoe both with over 4,000 million miles. Weld, Douglas, Larimer and Boulder rank 5th through 8th for VMT with between 3,000 and 4,000 million miles. The remaining five counties have much lower VMT, between 61 million miles (Gilpin) and 662 million miles (Broomfield).

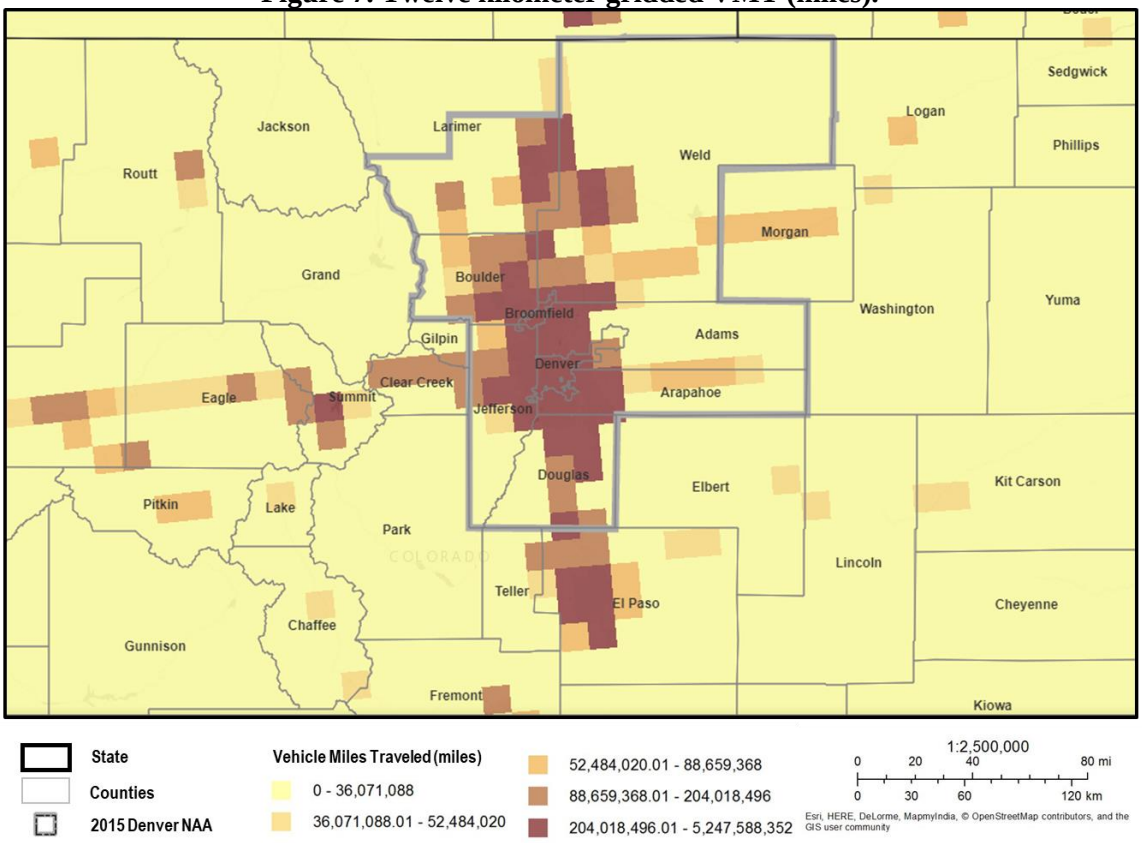
Table 5. Traffic and Commuting Patterns.

County	State Recommended Nonattainment?	2014 Total VMT (Million Miles)	Number of County Residents Who Work	Number Commuting to or Within Counties with Violating Monitor(s)	Percentage Commuting to or Within Counties with Violating Monitor(s)
Denver, CO	Yes	5,682	299,489	46,991	16%
Jefferson, CO	**Yes**	**4,704**	281,748	107,071	**38%**
Adams, CO	Yes	4,480	215,675	34,433	16%
Arapahoe, CO	Yes	4,344	287,328	47,507	17%
Weld, CO	Yes (partial)*	2,991	133,199	27,638	21%
Douglas, CO	**Yes**	**2,959**	152,852	53,487	**35%**
Larimer, CO	**Yes (partial)***	**2,721**	140,317	91,342	**65%**
Boulder, CO	Yes	2,266	134,407	13,689	10%
Broomfield, CO	Yes	662	30,775	4,862	16%
Clear Creek, CO	No	503	4,459	1,187	27%
Elbert, CO	No	270	12,866	3,184	25%
Park, CO	No	223	6,735	1,644	24%
Gilpin, CO	No	61	2,432	465	19%
	Total:	31,866	1,702,282	433,500	25%

* For state recommended partial counties, the data provided are for the entire county.
Counties with a monitor(s) violating the NAAQS are indicated in bold.

To show traffic and commuting patterns, Figure 7 displays twelve-kilometer gridded VMT from the 2014 NEI. The darker colors in the figure represent more VMT, and the higher VMT areas mostly correspond to densely populated cities and towns as well as major highways (such as Interstate-25 running north-south along the Front Range and Interstate-70 running east-west through the center of the figure).

Figure 7. Twelve kilometer gridded VMT (miles).



Factor 3: Meteorology

Evaluation of meteorological data helps to assess the fate and transport of emissions contributing to ozone concentrations and to identify areas potentially contributing to the violating monitors. Results of meteorological data analyses may inform the determination of nonattainment area boundaries. Therefore, the discussion of the meteorology factor includes detailed information on the local meteorology of northeastern Colorado during high ozone days, the presentation and discussion of pollution roses, and an analysis of HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory model) back trajectories for violating monitors.

Ozone in the DM/NFR area tends to be elevated during periods of rising 500 hectopascal (hPa) heights where large-scale (or synoptic-scale) forcing is weak, leaving microscale meteorological conditions to become the main driver in wind flow patterns.[11] The 500 hPa height is the height of the atmosphere where the 500 hPa pressure level is measured. High-pressure systems are associated with rising 500 hPa heights and are a typical synoptic meteorology set up for high summertime ozone days in the western U.S. due to clear skies, calm winds (reduced westerly winds), and warm temperatures at the surface. High-pressure systems allow for more localized, terrain-driven meteorological circulations to play a role, more so than if there was a synoptic scale disturbance such as a trough or low-pressure system. Research has shown increased 500 hPa heights, correlating with high summertime ozone, are more evident in higher altitude urbanized locations such as the DM/NFR.[12]

[11] Reddy and Pfister, 2016, "Meteorological factors contributing to the interannual variability of midsummer surface ozone in Colorado, Utah, and other western U.S. states," Full citation included in the Colorado 2016 TSD at p. 45.
[12] Reddy and Pfister, 2016.

The Colorado 2016 TSD identifies the three key circulations affecting summer air quality within the airshed as:

- Nighttime and early-morning down-valley drainage flow.[13]
- Thermally-driven upslope flow which is a component of a mountain-valley circulation.[14]
- Mountain-plains solenoid circulation.[15]

The EPA identified one more circulation pattern that can affect summer air quality within the airshed:

- The Denver Convergence Vorticity Zone,[16] or "Denver Cyclone"

All four of these circulations are discussed below.

Nighttime and early-morning down-valley drainage flow

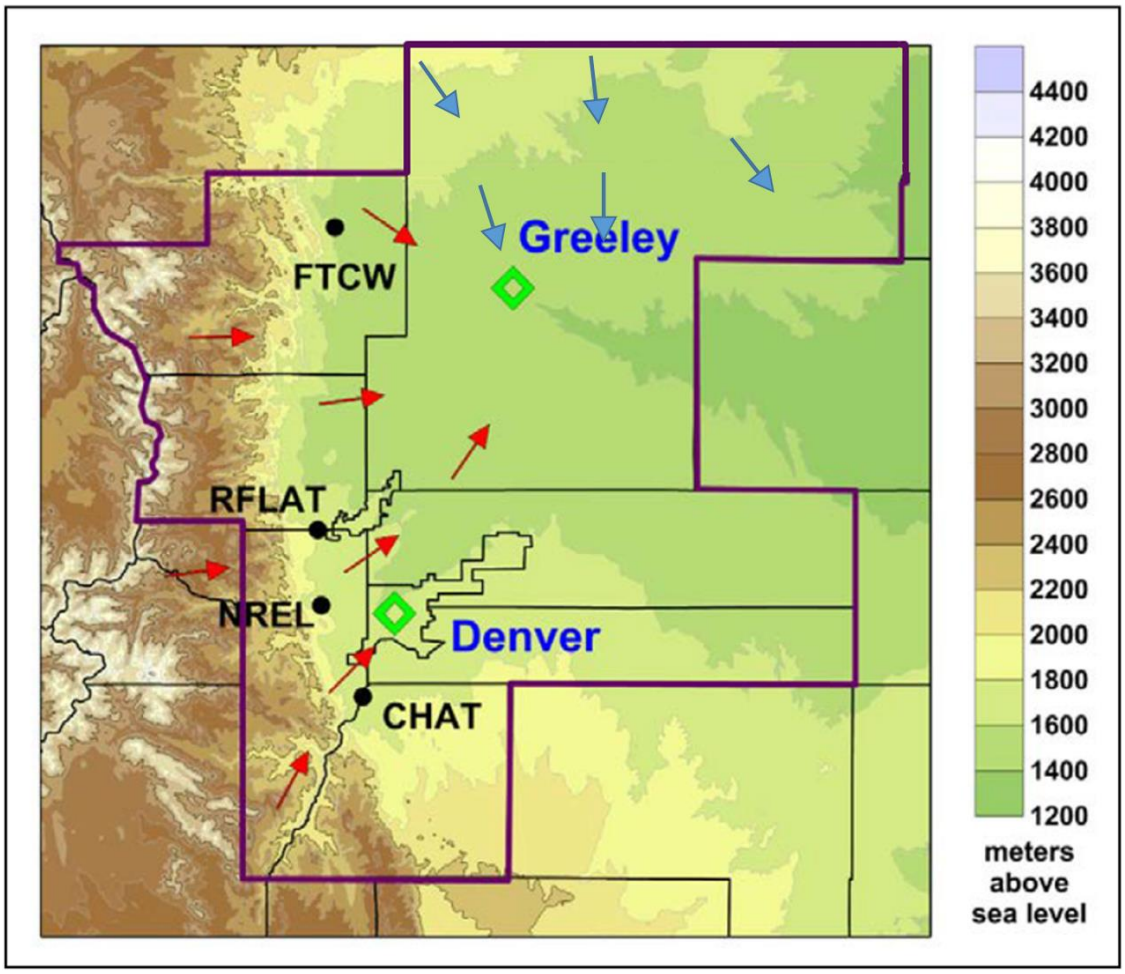
The Colorado 2016 TSD describes the nighttime and early-morning downslope (also referred to as down-valley for the purposes of this discussion) drainage flow as the following:

> At night, infrared radiation from the surface disproportionately cools the ground and the air next to it as compared to air further up in the atmosphere. This chilled air is denser than surrounding air and flows downhill. These downhill flows converge to form drainage winds that move surface air down the canyons and valleys toward a widening of the Platte Valley in Weld County (see Figure 1-20). There the wider valley and a constriction further downstream, cause pooling of cooler air. Both the drainage winds and the cold pooling trap nighttime and early morning emissions. This phenomenon contributes to the accumulation of emissions that later react to form ozone in the presence of sunlight and the daytime mountain-valley circulation during the afternoon.

Colorado also provides Figure 8 to help illustrate the down-valley drainage, with the red arrows depicting the direction of expected flow. The EPA added the nonattainment area boundary and the blue arrows near the northern portion of Weld County to illustrate the influence of the Cheyenne Ridge topography and associated drainage features that are discussed in the geography/topography factor analysis (and further illustrated in Figure 17 and Figure 18). The position and orientation of these blue arrows are the EPA's interpretation of the data presented in Toth and Johnson (1985).[17]

[13] Colorado 2016 TSD p. 34, *see* Figure 1-20.
[14] Colorado 2016 TSD p. 34, *see* Figure 1-21.
[15] Colorado 2016 TSD p. 35.
[16] "Denver Convergence-Vorticity Zone." *American Meteorological Society*, accessed on January 9, 2021 at *https://glossary.ametsoc.org/wiki/Denver_convergence-vorticity_zone*.
[17] Toth and Johnson, 1985, "Summer surface flow characteristics over northeast Colorado," Full citation included in the Colorado 2016 TSD at p. 45.

Figure 8. Nighttime down-valley drainage flow.



FTCW = Fort Collins West; RFLAT = Rocky Flats; NREL = National Renewable Energy Lab; CHAT = Chatfield

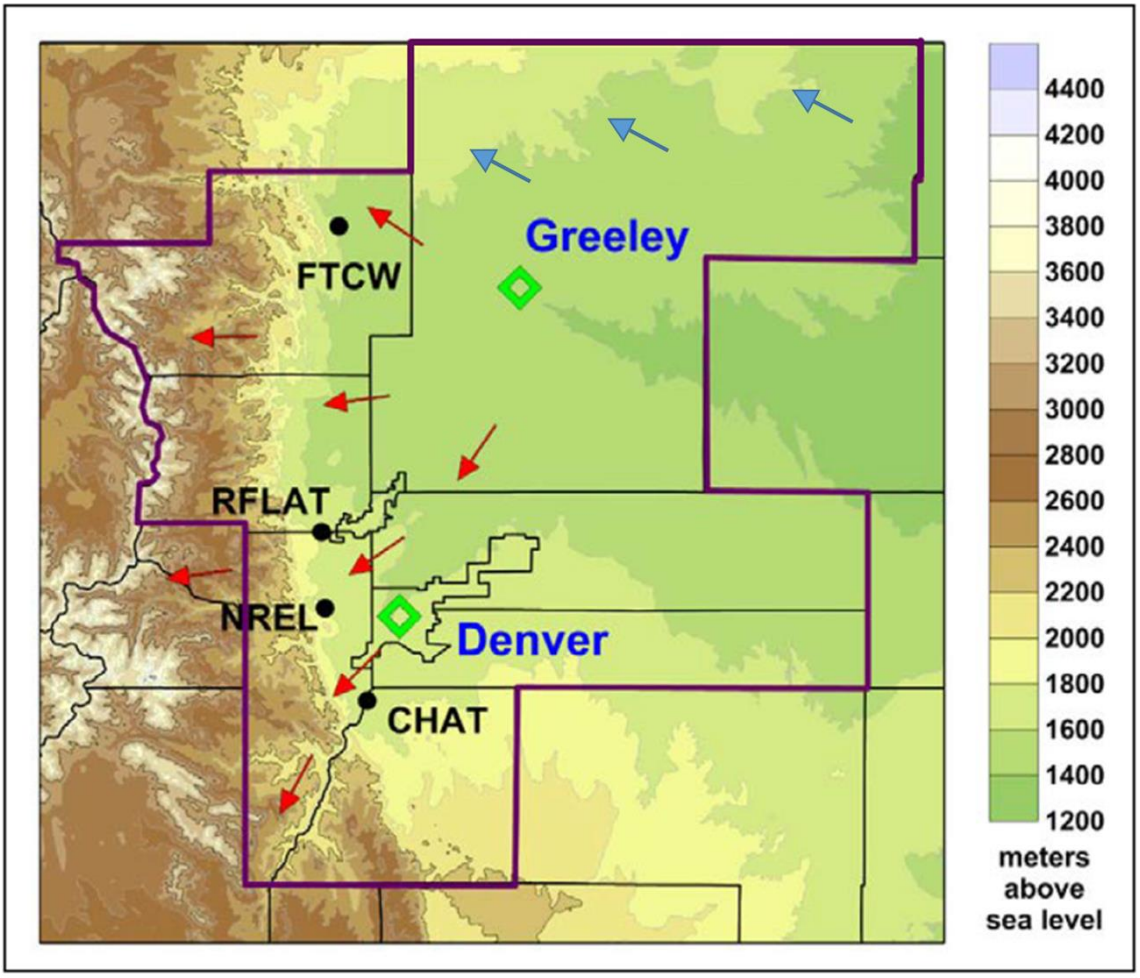
Thermally-driven upslope and up-valley flows

Thermally-driven upslope and up-valley flow, being the opposite in direction of the nighttime downslope drainage flow, occurs during relatively clear days resulting from the disproportionate solar heating of the earth's surface and the air next to it as compared to air higher in the atmosphere. The warm air rises in an up-slope direction from the horizontal temperature gradient of thermal heating of the slope. This heating and rising motion results in upslope winds in mountainous areas. In the Denver Basin and western mountains, it has been observed that the upslope flow starts on the east-facing foothills in the morning prior to the up-valley winds propagating eastward to the plains by mid-day.[18] Upslope winds along a mountainside are typically strongest around mid-morning when the largest differential heating is occurring. As a valley is heated throughout the day and becomes warmer than adjacent plains, up-valley winds flow will continue into the later afternoon even after the upslope on the steeper slopes has diminished. Both contribute to the mountain-valley wind system along with downslope and down-valley winds. Unlike the nighttime and early-morning down-valley drainage flow, these up-valley winds can overwhelm the local thermally driven winds. Colorado provides Figure 9 in their TSD to help illustrate

[18] Toth and Johnson, 1985.

the upslope and up-valley flow, with the red arrows depicting the direction of expected flow. The EPA added the nonattainment area boundary and the blue arrows to this figure to depict the motion of these winds one would expect in the northern area of the nonattainment area boundary. Again, the position and orientation of these blue arrows are the EPA's interpretation of the data presented in Toth and Johnson (1985).

Figure 9. Thermally-driven upslope and up-valley flow.



FTCW = Fort Collins West; RFLAT = Rocky Flats; NREL = National Renewable Energy Lab; CHAT = Chatfield

Both Figure 8 and Figure 9 are simplified, as there are considerable transition periods before daytime upslope flow and before nighttime drainage flow. During these transition periods one would expect more variability in the wind directions.

Mountain plains solenoid circulation

The mountain plains solenoid circulation is also described in the Colorado 2016 TSD:

> The solenoid circulation consists of thermally-driven surface upslope flow (toward the southwest, west, and northwest) to mountain top level during the afternoon, mixing and transporting vertically, and weak transport to the east at higher altitudes. Vertical mixing and subsidence over plains near Denver closes this loop, tending to keep ozone in the area. Light winds, a deep layer

of thermally-driven upslope flow, local vertical recirculation, cloud-free skies, and warm temperatures are key ingredients for high ozone at the surface.

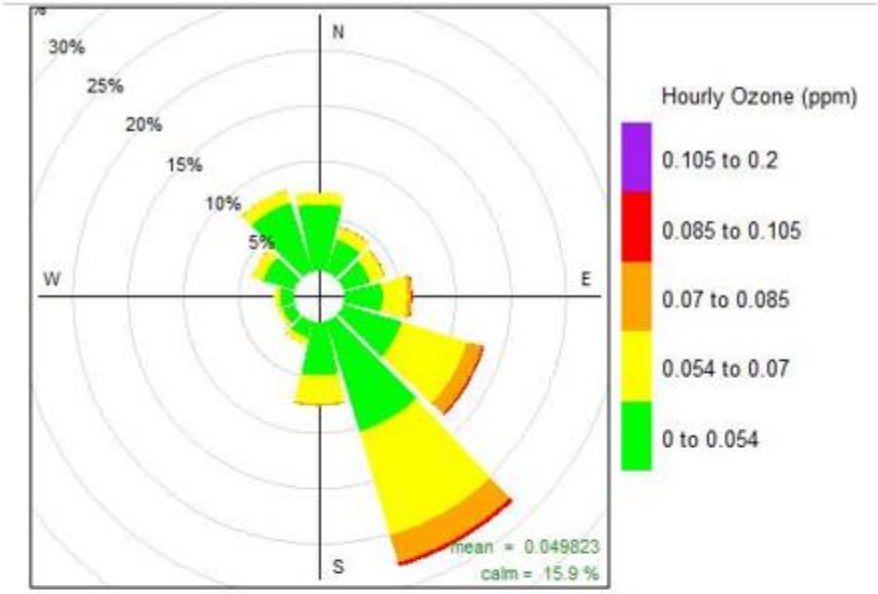
Denver Cyclone

The Denver Cyclone is a cyclonic (counterclockwise) atmospheric motion that is an orographically-driven low pressure event. The Denver Cyclone results from the interaction of local meteorology with the topography of the Denver Basin; where down-sloping wind primarily forced from the Palmer Divide and the Continental Divide, create a low pressure circulation which can have an impact on localized pollution transport due to mesoscale winds. The event is not a static feature however, and its motion is fluid in the atmosphere. The Denver Cyclone does not predict localized wind but during these low pressure events, the system that forms does have cyclonic motion. For example, Fort Collins, in the northwest portion of the nonattainment area, will often have a wind component from the north or northeast, while an area in the southeastern portion of the nonattainment area will have a wind component from the south or southwest. Minor shifts in the mesoscale and synoptic patterns will affect the oscillation of the low pressure center throughout the nonattainment area. Surface winds are important for ozone and precursor transport and may be strongly influenced by local terrain leading to wind directions different from the flow further aloft.

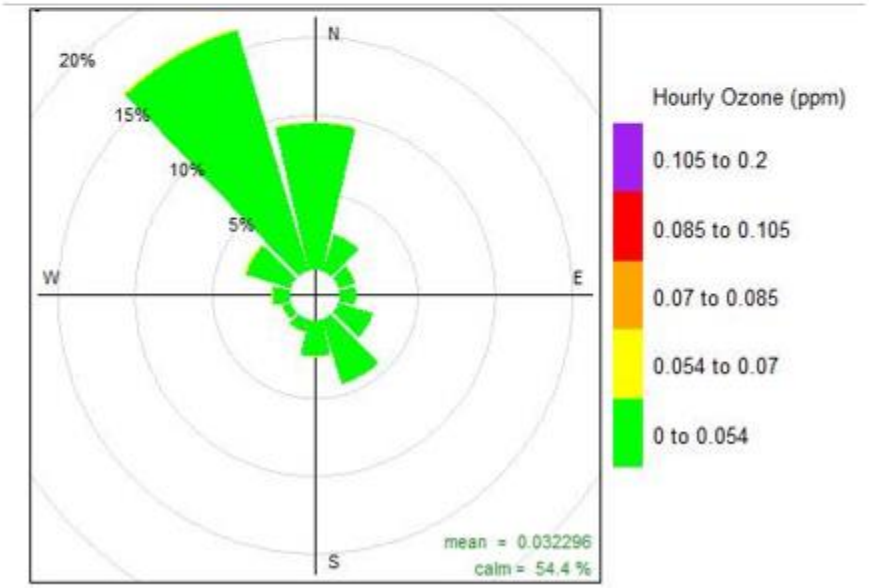
These four circulation patterns (drainage/down-valley flow, upslope/up-valley flow, mountain-plains solenoid circulation, and the Denver Cyclone), in conjunction with the surface topography in the area serve to trap emissions and produce ozone in the basin formed by the surrounding higher elevation features. Furthermore, these circulation patterns serve to recirculate prior day emissions and ozone into the Denver area population centers as the mountain-plains solenoid flow lifts the polluted atmosphere up the mountain slopes of the Rocky Mountains to the west in warm afternoons, and then returns the polluted air to the surface as the lofted air circulates back to the east and subsides overnight. The thermally-driven upslope flow, flowing upstream along the South Platte River valley in the afternoon from northeast to southwest and along the Cache la Poudre valley from southeast to northwest, serves to close off the three sided basin formed by the elevated terrain to the south, west and north. These topographic features are discussed further in the geography/topography factor analysis.

A pollution rose which combines the hourly ozone concentration data and local hourly wind direction at the Fort Collins West site exemplifies the influence of local terrain and resulting upslope flow on high ozone transport (Figure 10). This site is located in the northwest portion of the nonattainment area and is the closest violating monitor to the northern nonattainment boundary. The local topography is dominated by the foothills a few miles to the west and the Cache la Poudre watershed which drains to the southeast. The Cache la Poudre is less than two miles from the monitor site, and during upslope flow conditions one would expect southeasterly flow up this watershed. As illustrated in the figure, virtually all of the hourly ozone values exceeding 0.070 ppm are transported from the south-southeast to east directions between the hours of 7:00 am and 9:00 pm MST. In contrast, between 10:00 pm and 6:00 am, ozone greater than 0.054 ppm is rarely observed, and dominant winds are northwesterly, down the Cache la Poudre drainage. The lower nighttime ozone concentrations are expected, as ozone formation is largely driven by photochemistry, but the 10:00 pm and 6:00 am pollution rose helps illustrate the nighttime and early-morning down-valley drainage flow at the site.

Figure 10. Fort Collins West pollution rose of hourly ozone during daylight hours (7:00 am to 9:00 pm MST top), and nighttime hours (10:00 pm to 6:00 am, bottom) during the ozone season (May – September) from 2013 through 2016.



Top: 7:00 am to 9:00 pm, MST



Bottom: 10:00 pm to 6:00 am, MST

To determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of ozone and precursor emissions from sources in the area, the EPA evaluated 2014-2016 HYSPLIT trajectories at 100, 500, and 1000 meters above ground level that illustrate the three-dimensional paths traveled by air parcels to a violating monitor. According to the EPA's ozone designations guidance:

When HYSPLIT trajectories are produced for specific monitor locations for days of high ozone concentrations (e.g., daily maximum 8-hour values that exceed the NAAQS), the results illustrate the potential source region for the air parcel that affected the monitor on the day of the high concentration. While HYSPLIT is a useful tool for identifying meteorological patterns associated with exceedance events, HYSPLIT trajectories alone do not conclusively indicate contribution to measured high concentrations of ozone. Therefore, they cannot be used in isolation to determine inclusion or exclusion of an area within a nonattainment boundary. While a HYSPLIT trajectory analysis alone cannot yield a conclusion that a particular region contributes to ozone concentrations, a set of HYSPLIT trajectories that show no wind flow from a particular region on any day with high ozone concentration measurements might provide support for discounting that region as contributing to ozone concentrations. HYSPLIT trajectories are very useful in combination with information on the location and magnitude of ozone precursor emissions sources.

Figure 11 through Figure 15 show the 24-hour HYSPLIT back trajectories for each exceedance day (i.e., daily maximum 8-hour values that exceed the 2015 ozone NAAQS) for the violating monitors within the area of analysis.

Figure 11. HYSPLIT back trajectories for Rocky Flats (violating monitor).

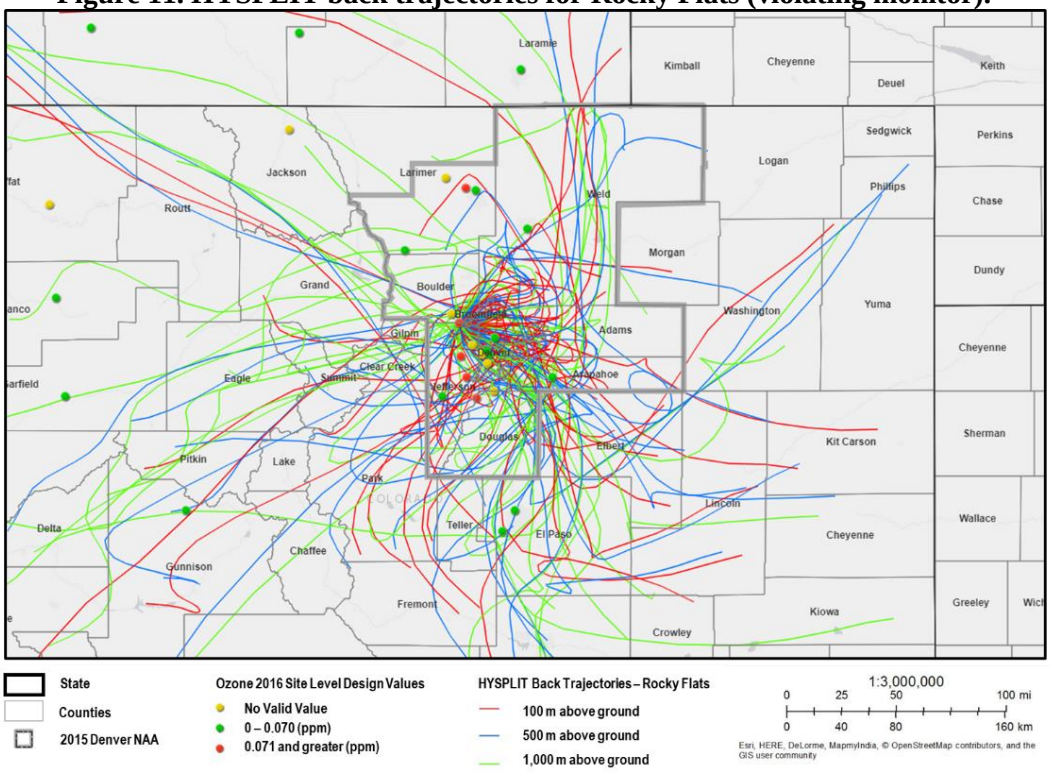


Figure 12. HYSPLIT back trajectories for NREL (violating monitor).

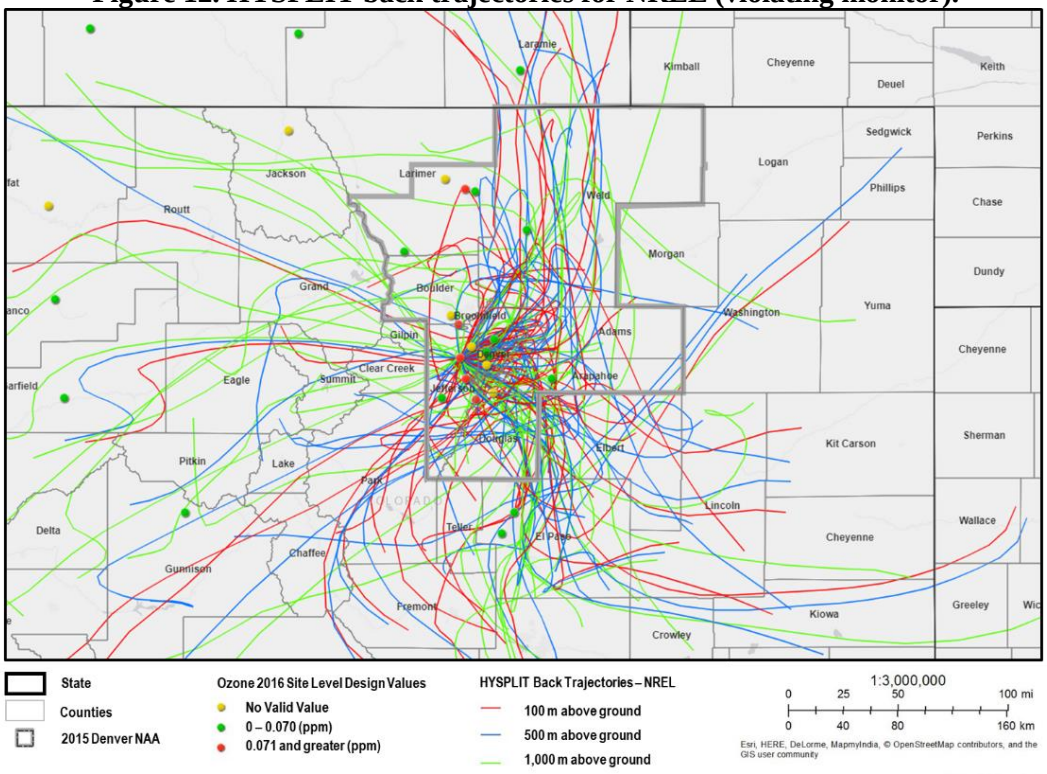


Figure 13. HYSPLIT back trajectories for Welch (violating monitor).

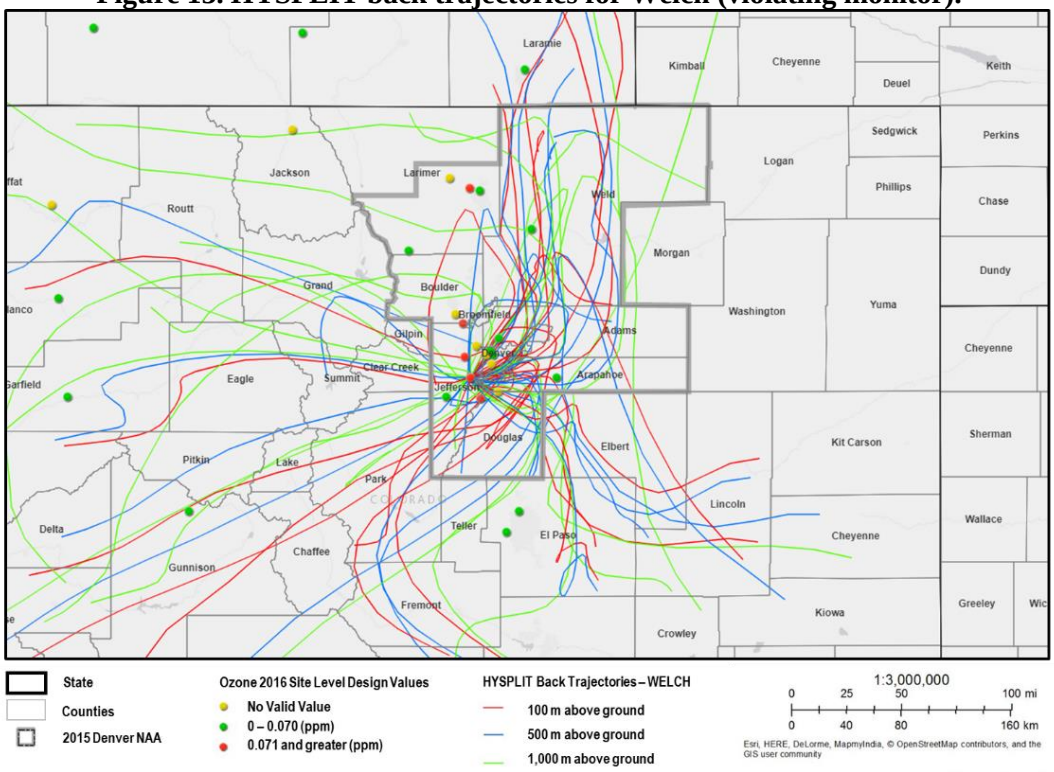


Figure 14. HYSPLIT back trajectories for Chatfield (violating monitor).

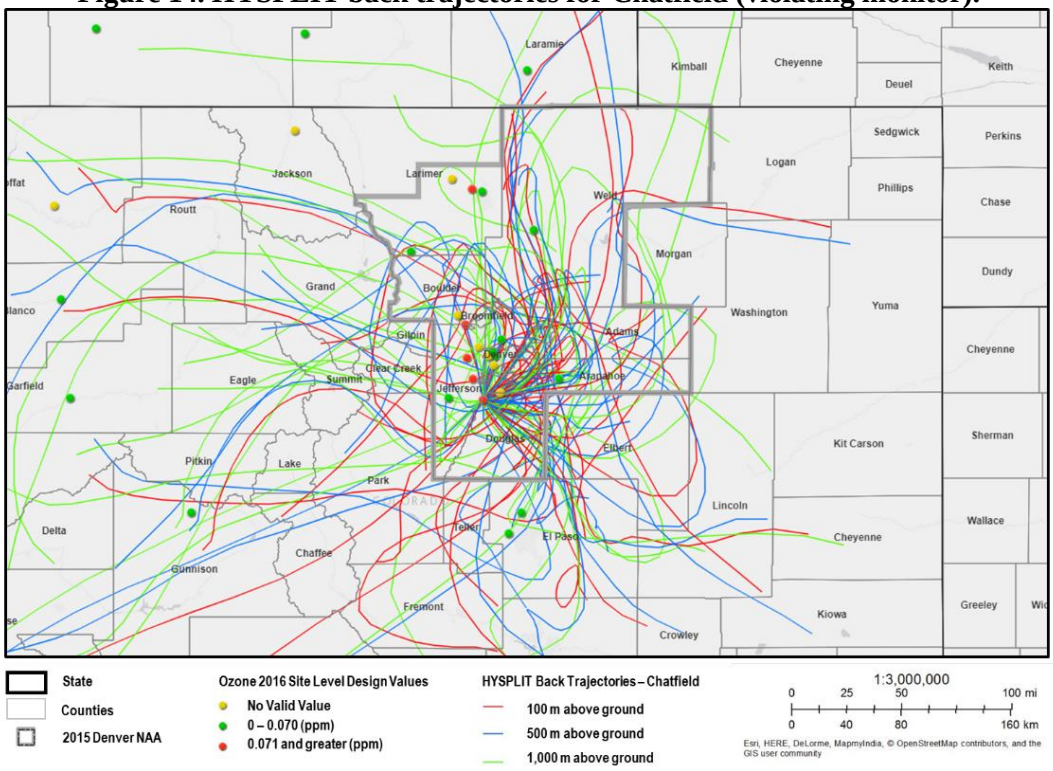


Figure 15. HYSPLIT back trajectories for Fort Collins West (violating monitor).

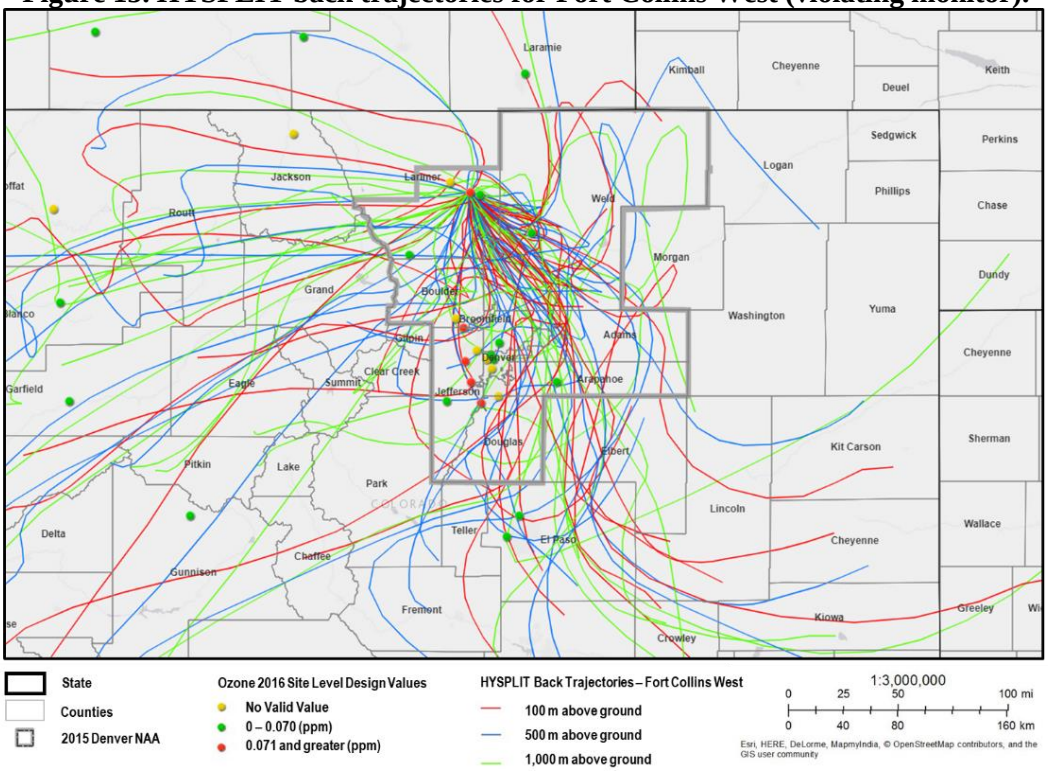


Figure 11 through Figure 15 show areas of highest density, where the largest number of trajectories transect, to the east of the violating monitors. For Chatfield, at the south end of the Denver metro area in Figure 14, the heaviest concentration of trajectories is to the northeast; for Fort Collins West, at the north end of the nonattainment area in Figure 15, the greatest concentration of trajectories lies to the southeast. All of these figures, to a varying degree, show trajectories initiating in or transecting the northern portion of Weld County.

The Colorado 2016 TSD independently evaluated HYSPLIT back trajectories. The Colorado methodology included results for Fort Collins West, Rocky Flats, NREL, and Chatfield for the four highest ozone events at each site each year from 2013-2015 (with data flagged as exceptional events excluded). They also included composite images and numeric evaluations of trajectory locations, allowing more focused interpretation and depiction of the HYSPLIT trajectory data.[19] Although the Colorado figures may be easier to interpret, unlike Figure 11 through Figure 15 of this TSD they do not include back trajectories from Welch, back trajectories from 2016, or back trajectories from exceedance days that were ranked lower than the 4th maximum for each year. All of these data are important to identifying potential source regions for the air parcel that affected the monitor on the day of the high concentration., and therefore, Figure 11 through Figure 15 were more heavily considered in this TSD.

Factor 4: Geography/topography

Consideration of geography or topography can provide additional information relevant to defining nonattainment area boundaries. Analyses should examine the physical features of the land that might define the airshed. Mountains or other physical features may influence the fate and transport of emissions as well as the formation and distribution of ozone concentrations. The absence of any such geographic or topographic features may also be a relevant consideration in selecting boundaries for a given area.

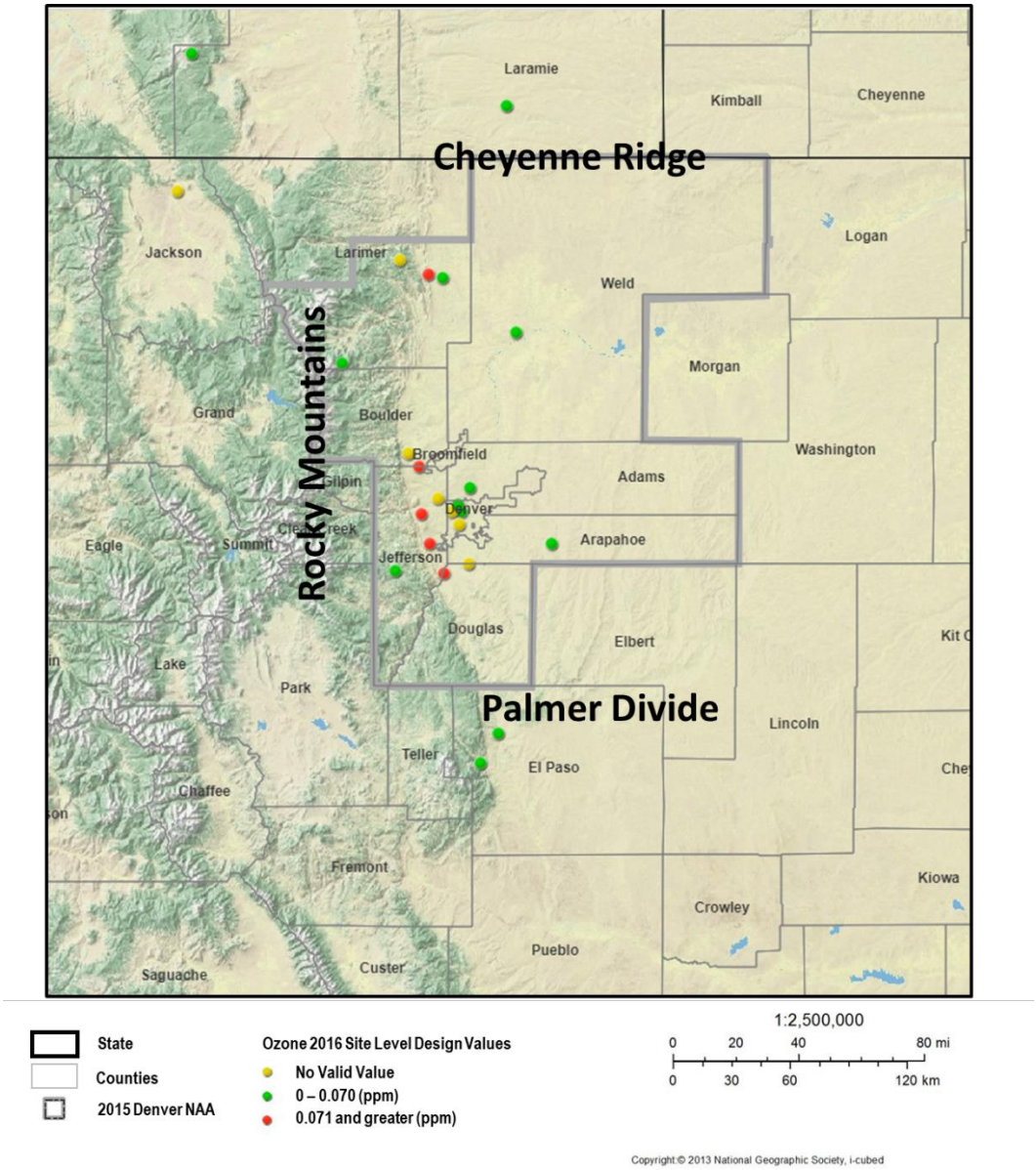
There are a number of topographic features within and around the area of analysis that provide additional information relevant to defining nonattainment area boundaries. The EPA used this geography/topography analysis to evaluate the physical features of the land that might affect the airshed and, therefore, the distribution of ozone over the area.

The relevant geographic and topographic features (Figure 16) include the following, and each of these features is discussed in more detail below:

- the Rocky Mountains to the west;
- the Palmer Divide to the south;
- the Cheyenne Ridge to the north;
- and the S. Platte River valley extending from the southwest to the northeast.

[19] Colorado 2016 TSD p. 35-43. *See* Figures 1-23 through 1-29.

Figure 16. Topographic illustration of the physical features with the 2016 design values and 2015 Denver nonattainment area.



The Palmer Divide, Rocky Mountains and Cheyenne Ridge are topographic features which surround three sides of the DM/NFR area to the south, west and north respectively (Figure 17). These three features create a three-sided basin that is open to the eastern plains and is commonly referred to as the Denver Basin. The S. Platte River flows from the southwest to the northeast through the Denver Basin, and forms what is referred to as the S. Platte River valley (which is visible in Figure 18).

Figure 17. Topography of eastern Colorado[20]

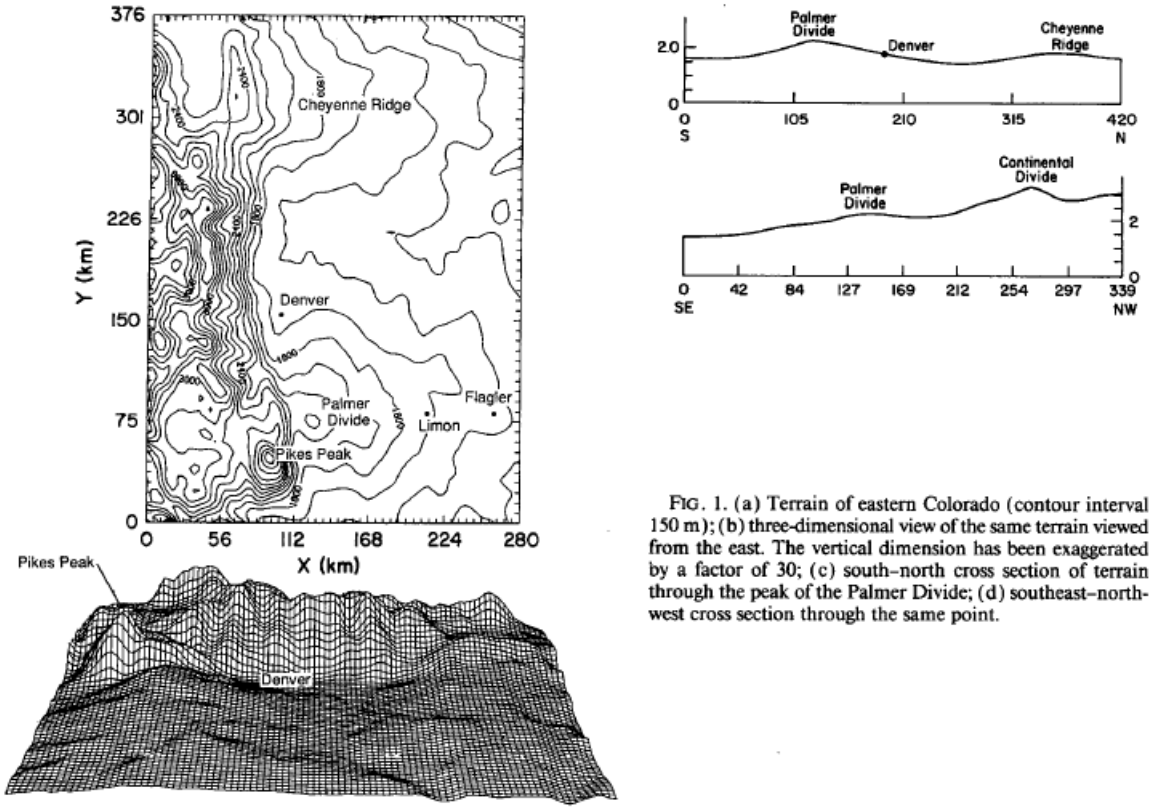
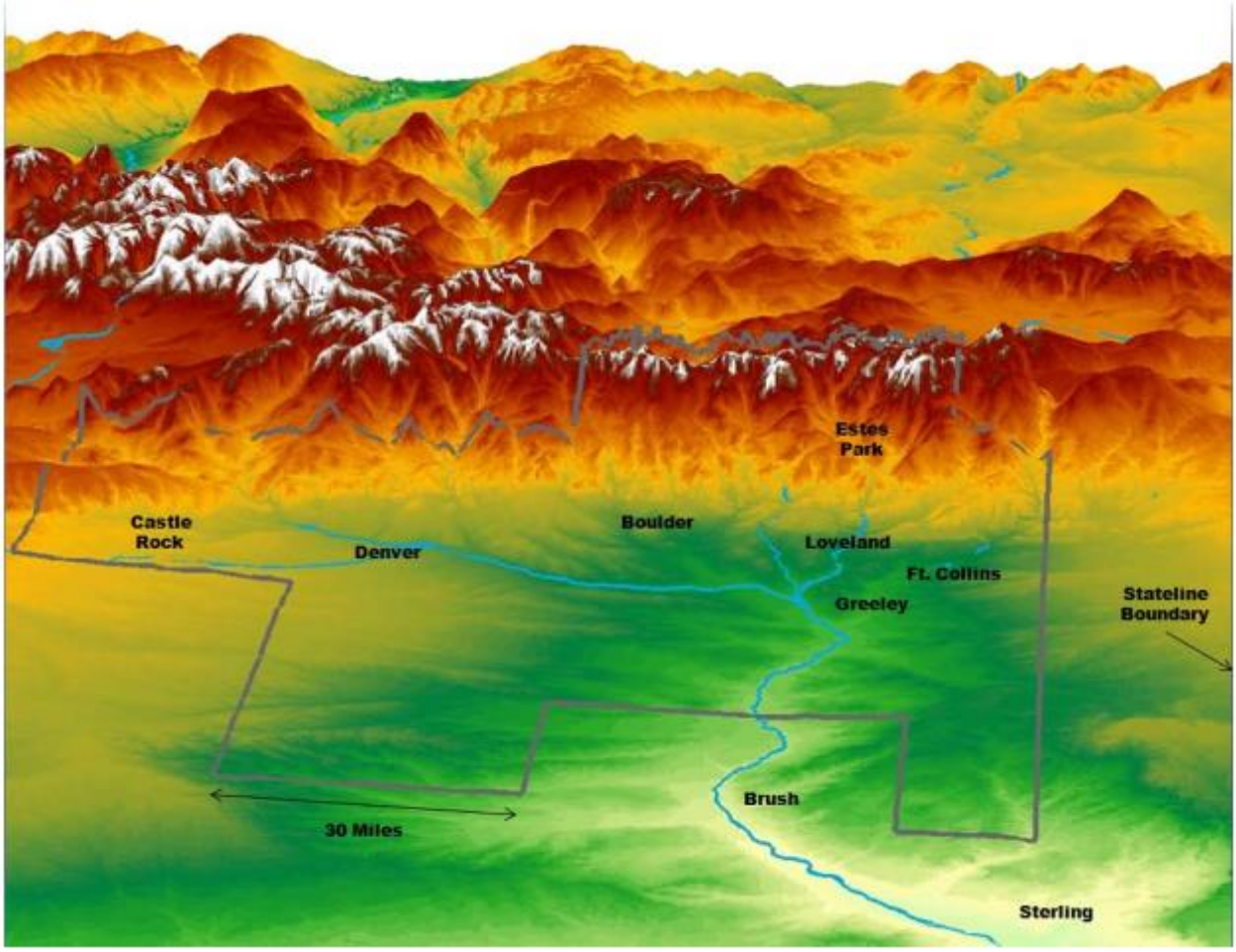


FIG. 1. (a) Terrain of eastern Colorado (contour interval 150 m); (b) three-dimensional view of the same terrain viewed from the east. The vertical dimension has been exaggerated by a factor of 30; (c) south–north cross section of terrain through the peak of the Palmer Divide; (d) southeast–northwest cross section through the same point.

[20] Crook et al. 1990, "The Denver Cyclone. Part 1: generation in low Froude number flow", Full citation included in the Colorado 2016 TSD on page 45.

Figure 18. The Denver Basin and state-recommended nonattainment area[21]



The Palmer Divide is an east-west oriented ridge that extends from the foothills of the Rocky Mountains out to the east. The elevation varies along the ridgeline, but generally decreases from the west to the east. The ridge forms the watershed boundary between the Arkansas River to the south and the South Platte River to the north and serves as a natural topographic break between the Denver Metro Area and Colorado Springs Metro Area. The Palmer Divide also roughly coincides with the southernmost boundary of the nonattainment area for the 1997 and 2008 ozone NAAQS and the boundary recommended by the State for the 2015 ozone NAAQS.

The continental divide of the Rocky Mountains is the watershed boundary between the Pacific Ocean and Atlantic Ocean (including those streams that drain into the Gulf of Mexico and the Caribbean Sea). It is a very mountainous part of Colorado and includes many peaks over 13,000 feet in elevation. The continental divide roughly coincides with the western boundary of the nonattainment area for the 1997 and 2008 ozone NAAQS and the boundary recommended by the State for the 2015 ozone NAAQS.

The Cheyenne Ridge is an elevated area of land that extends from the foothills of the Rocky Mountains eastward generally parallel to the Colorado-Wyoming border. The Cheyenne Ridge is north of the nonattainment area boundary recommended by the State for the 2015 ozone NAAQS. Because this topographic feature is important to the airshed but does not line up with the northern boundary

[21] Colorado 2016 TSD p. 46, Figure 1-31.

recommended in the Colorado 2016 TSD, and because this feature was specifically mentioned in the court remand, the EPA has presented more topographic analysis of the Cheyenne Ridge than the other topographic features in this section.

The Cheyenne Ridge is a west-northwest to east-southeast ridgeline around the border of Colorado and Wyoming. As illustrated in Figure 17, the Cheyenne Ridge is a wide elevated area that has no clear ridgeline. Similar to the Palmer Divide, the elevation of the Cheyenne Ridge generally decreases from the west to the east, but it is not as high and well defined. As a result, the southern side of the Cheyenne Ridge slopes in various directions depending on your location along the ridge. The western portion of the ridge slopes to the southeast down towards the Denver Basin and the S. Platte River Valley whereas the eastern portion of the Cheyenne Ridge slopes more towards the southeast and east.

The surface topography of the Cheyenne Ridge and its southern slopes play an important role in the circulation patterns of the atmosphere within the airshed. As discussed in the meteorology factor analysis, nighttime and early-morning down-valley drainage flow from this slope can transport emissions downslope and down-valley. One would expect the down-valley drainage flow along most of the Cheyenne Ridge would transport emissions towards S. Platte River valley floor within the Denver Basin. In addition, the Cheyenne Ridge has been shown to be the northernmost topographic feature that has an important influence on the location and persistence of the Denver Cyclone.[22]

Factor 5: Jurisdictional Boundaries

Once the geographic extent of the violating area and the nearby area contributing to violations is determined, the EPA considered existing jurisdictional boundaries for the purposes of providing a clearly defined legal boundary to carry out the air quality planning and enforcement functions for nonattainment areas. In defining the boundaries of the DM/NFR nonattainment area, the EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Examples of jurisdictional boundaries include, but are not limited to counties, air districts, areas of Indian country, metropolitan planning organizations, and existing nonattainment areas. If an existing jurisdictional boundary is used to help define the nonattainment area, it must encompass the area that has been identified as meeting the nonattainment definition. Where existing jurisdictional boundaries are not adequate or appropriate to describe the nonattainment area, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the designated areas.

The Denver area has previously established nonattainment area boundaries associated with the 1997 and 2008 ozone NAAQS, and the State has recommended the same boundary for the 2015 ozone NAAQS. The EPA considered this boundary for the purposes of providing consistency and a clearly defined legal boundary for the nonattainment area, but ultimately determined that including the entirety of Weld County in the nonattainment area is necessary. Weld County is the largest county in the area of analysis, and including all of Weld County in the nonattainment area extends the nonattainment area boundary north by approximately 20 miles. Regardless, the northern border of the county is a clearly defined legal boundary within the area of analysis and extending the boundary this far is necessary to effectively encompass the emission sources contributing to the violating monitors (as detailed in the emissions factor analysis).

[22] Crook et al. 1990.

Conclusion for Denver Metro/North Front Range Area

Based on the assessment of factors described above, the EPA is modifying the State's recommendation to designate the following counties or partial counties as the DM/NFR nonattainment area for the 2015 ozone NAAQS: Adams County, Arapahoe County, Boulder County, Broomfield County, Denver County, Douglas County, Jefferson County, Larimer County (partial), and Weld County. These are the same counties that are included in the Denver nonattainment area for the 1997 and 2008 ozone NAAQS, but the final area also includes the northern portion of Weld County. The air quality data factor analysis shows that Douglas, Jefferson, and Larimer Counties contain monitors in violation of the 2015 ozone NAAQS, therefore all or portions of Douglas, Jefferson, and Larimer County are included in the nonattainment area. Adams, Arapahoe, Boulder, Broomfield, Denver, and Weld County do not contain violating monitors, but the EPA has concluded that these areas are nearby those counties that do have violating monitors and based on the other factor analyses they contribute to the ozone concentrations in violation of the 2015 ozone NAAQS.

The emissions factor analysis shows that most of the oil and gas wells, large and small point sources, population (and population density and growth), and VMT in the area of analysis are captured by this nonattainment area. Weld, Adams, Denver, Jefferson, Arapahoe, Boulder, Larimer (partial), and Douglas Counties are included in the nonattainment area and rank 1-8 in terms of total NOx and VOC emissions. These counties also rank high as compared with other counties in the area of analysis in terms of total population, population density, and population growth. This factor analysis also shows that 41% of the Weld County controllable NOx and 78% of the controllable VOC come from Oil and Gas. The large percentage of controllable NOx and VOC emissions from Oil and Gas in Weld County and the presences of approximately 8% of the county's oil and gas wells in northern Weld County suggest large NOx and VOC production in the northern portion of Weld County as compared with other counties in the area of analysis. The northern portion of Larimer County is excluded from this nonattainment area, as the county has much less total NOx and VOC emissions (about 12% of the emissions of Weld County) and oil and gas only accounts for about 2% of the total county NOx and VOC emissions.[23] Furthermore, the northern portion has a much smaller percentage of large and small point sources, population, and VMT than the southern portion of the county. These facts all suggest that Larimer county has much less emissions than Weld County and the majority of emissions are contained within the southern portion of Larimer County.

The meteorology factor analysis and the geography/topography factor analysis illustrate how the unique topographic features forming the Denver Basin (the Rocky Mountains to the west, the Cheyenne Ridge to the north and the Palmer Divide to the south and the S. Platte River) influence local meteorology which can trap emissions and produce ozone in the nonattainment area. The nighttime drainage flow pools emissions in the basin and the daytime upslope flow pushes the emissions through the urbanized and industrialized regions of the airshed to the area of the violating monitors on the west slopes of the basin. Additional circulations (i.e., solenoid and Denver Cyclone) enhance the trapping and recirculation of emissions and locally produced ozone. The pollution roses confirm that nearly all the high hourly ozone values at the Fort Collins West monitor result from air being transported up the Cache la Poudre drainage in the daytime during the ozone season. Finally, the HYSPLIT back trajectory analyses suggest that during periods of high ozone, most of the air parcels that affect the violating monitors traverse locations concentrated near the center the Denver Basin and are contained by the nonattainment boundary over the prior 24 hours.

The EPA's 2015 ozone NAAQS designation promulgated on April 30, 2018, only included the southern portion of Weld County in the nonattainment area. Upon consideration of the Court's opinion and the subsequent re-evaluation of the five factor analyses, the EPA believes that including the northern portion

[23] See Table 1-2 of Colorado's 2016 TSD.

of Weld County in the nonattainment area is necessary. The 2018 TSD downplayed the contribution of the northern portion of Weld to the county's overall emissions and didn't effectively explain how local topography and meteorology prevent northern Weld from contributing to ozone NAAQS violations in the nonattainment area. This re-evaluation shows that Weld County has over 300% more total NOx and VOC emissions than the county with the second highest NOx and VOC emissions in the area of analysis and even has 37% more VOC emissions than all of the other counties in the area of analysis combined. Much of these emissions are from oil and gas activities which are present in both the northern and southern portion of the county. Furthermore, this re-evaluation asserts that there are no defining topographic or meteorological features that clearly exclude the northern Weld County emissions from contributing to all the violating monitors. On the contrary, this TSD shows that the northern portion of the county lies along the southern slope of the Cheyenne Ridge and argues that some fraction of emissions originating in this area would be expected to drain into the Denver Basin with the nighttime drainage flows and during times of other favorable meteorological conditions. The contribution of emissions from the northern portion of Weld County is further supported by the HYSPLIT back trajectories as presented in Figure 11 through Figure 15. These back trajectories suggest that air parcels impacting all the violating monitors during high ozone events may traverse the northern portion of Weld County during the prior 24 hours.

Based on the assessment of factors described above, the EPA has concluded that the following counties meet the CAA criteria for inclusion in the DM/NFR nonattainment area: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer (partial) and Weld. These are the same counties that are included in the DM/NFR nonattainment area for the 1997 and 2008 ozone NAAQS, but the final area also includes the northern portion of Weld County. The State did not recommend Clear Creek, Elbert, Gilpin, and Park Counties for inclusion in the nonattainment area. These counties all ranked among the lowest for emissions, population-related information, and traffic and commuting. Furthermore topography (and local meteorology) separates Clear Creek, Gilpin, and Clark from the core of the metropolitan area and the violating monitors. Therefore, the EPA is not modifying the State's recommendation for these counties.