Chapter Four – Visibility and Source Apportionment Modeling

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4.1 INTRODUCTION

The regional haze rule (RHR) requires states to "address regional haze in each mandatory Class I Federal area located within the State, and each mandatory Class I Federal area located outside the State which may be affected by emissions from within the State". The RHR also requires goals be established to "provide for reasonable progress toward achieving natural visibility conditions." CFR 40 Part 51.308(d) Air quality modeling analyses were performed to determine which Class I areas are affected by emissions from Nevada and to evaluate reasonable progress, as discussed in Chapter One. The Western Regional Air Partnership's (WRAP) Regional Modeling Center (RMC) performed these modeling analyses for the WRAP states, including Nevada.

Visibility modeling results indicate that the Jarbidge Wilderness Area (Jarbidge WA) will meet the Uniform Rate of Progress (URP) for 2018. The modeling results and technical analyses also indicate Nevada sources do contribute to visibility impairment at the Jarbidge WA, as well as Class I areas located in adjacent states. The modeling also indicates that out-of-state sources have the greatest impact on regional haze in Nevada. Regional weighted emissions potential (WEP) analyses indicate the significant role of emissions from wind blown and fugitive dust and natural fire in visibility impairment at the Jarbidge WA, thereby supporting the anecdotal observations of the Nevada Division of Environmental Protection (NDEP) staff discussed in Chapter One.

The visibility and source apportionment modeling described in this Chapter provides, in conjunction with the monitoring and emissions analyses, the technical basis used to identify and evaluate reasonable progress for the Jarbidge WA.

4.1.1 Air Quality Models

RMC utilized two grid-based models to analyze the effects of haze-causing particles within the WRAP area. The Community Multi-Scale Air Quality (CMAQ) model provided visibility modeling forecasts for 2018, the end of the first regional haze planning period. The results of CMAQ modeling are used in identifying the 2018 reasonable progress goals (RPG). The Particulate Matter Source Attribution Tracking (PSAT) algorithm in the Comprehensive Air Quality Model with Extensions (CAMx) model is used to assess source apportionment, particularly for sulfate and nitrate particle species, based on source area and source category, and to identify those Class I areas that are affected by Nevada emission sources.

The PSAT algorithm applies nitrate-sulfate-ammonia chemistry to a system of tracers, or "tags", to track chemical transformations, transport and removal of emissions. Each source area (state or region) is assigned a tag that is used to track the emissions from each 36-kilometer grid cell within the specified source area. Emissions from point, mobile, area and fire (natural and anthropogenic) source categories were tagged for each source area. The PSAT algorithm was also used, in a limited application (i.e., no source area attribution), to track natural and anthropogenic species of organic aerosols at each Class I area. The organic aerosol tracer tracked both primary and secondary organic aerosols (POA and SOA, respectively).

Meteorological inputs and emission inventories were prepared for 2002, chosen as representative of the baseline period 2000 through 2004. These inputs were used in the air quality model to predict fine particle mass and visibility. The model results for 2002 were compared with observed meteorological and air quality data to evaluate model performance. Several configurations of the meteorological and air quality model were evaluated to select the configuration that gave the best overall performance for the WRAP region. Once model performance was deemed adequate, the current and future year emissions were processed through the emissions model, as discussed in Chapter One. The modeled emissions scenarios are described in Chapters One and Three.

4.1.2 Model Performance Evaluation

The objective of the model performance evaluation was to compare model-simulated concentrations with observed data to determine whether the model's performance was sufficiently accurate to justify using the model for simulating future conditions, as discussed in Chapter One. The model was compared to ambient data for both particulate matter and gaseous species, for an annual time period and for a large number of sites. The model was evaluated for both the worst and best visibility conditions. The "Final Report for the WRAP 2002 Visibility Model Performance Evaluation" (Tonnesen, et al, 2006 can be found at http://pah.cert.ucr.edu/aqm/308/reports/final/2002_MPE_report_main_body_FINAL.pdf) discusses in detail how the model performance was evaluated.

The WRAP's RMC found the model over-predicted the observed data on the cleanest days (i.e., the 20 percent best days or best days) and under predicted the observed data on the most polluted days (i.e., the 20 percent worst days or worst days).

RMC has concluded that the CMAQ model cannot be used to forecast future coarse matter (CM) concentrations. Nevada has also deemed model performance was unacceptable for fine particulate matter (SOIL) on the worst days and nitrate on the best days. Model performance is discussed in greater detail below.

4.1.2.1 2002 Worst Days Performance

CMAQ model performance can be roughly judged by comparing the model predicted concentration (left side of Figure 4-1) against the monitored concentration from the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor JARB1 (right side of Figure 4-1) for the worst days of 2002. As shown, the model greatly under-predicts total mass and particularly CM (shown in gray on Figure 4-1). Similar model under-prediction is observed across the WRAP region, thus the RMC has concluded that the CMAQ model cannot be used to forecast future CM concentrations.

Figure 4-2 indicates the CMAQ model under predicts, as shown by negative percentages, all six components of extinction for the worst days at JARB1. Nevada deems model performance for the worst days is acceptable for sulfate (-32 percent), nitrate (-20 percent), organic matter (-40 percent), and elemental carbon (-33 percent), but is unacceptable for SOIL (-88 percent).

FIGURE 4-1

CMAQ MODEL PERFORMANCE FOR JARB1 2002 WORST DAYS

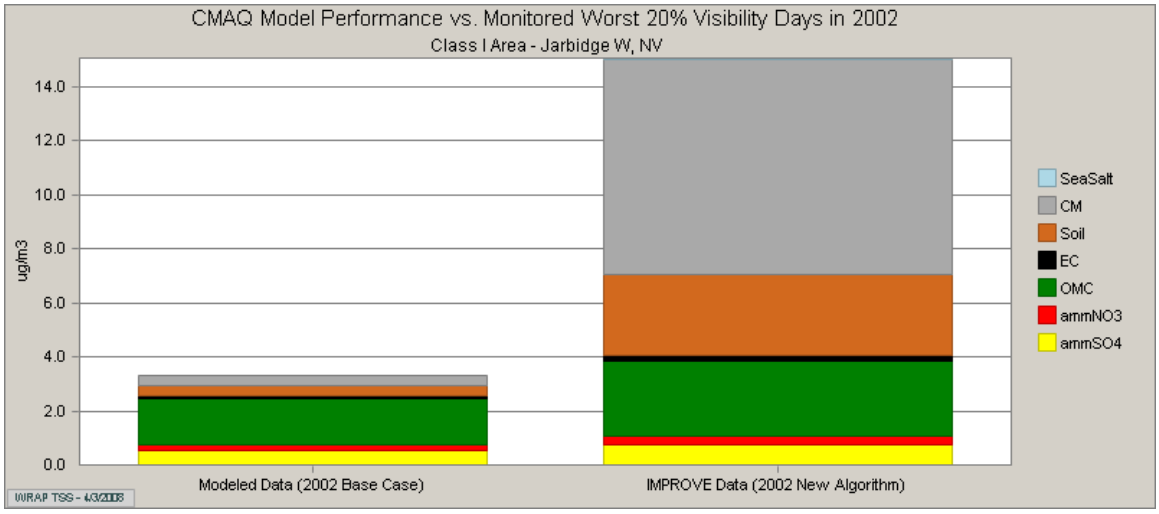
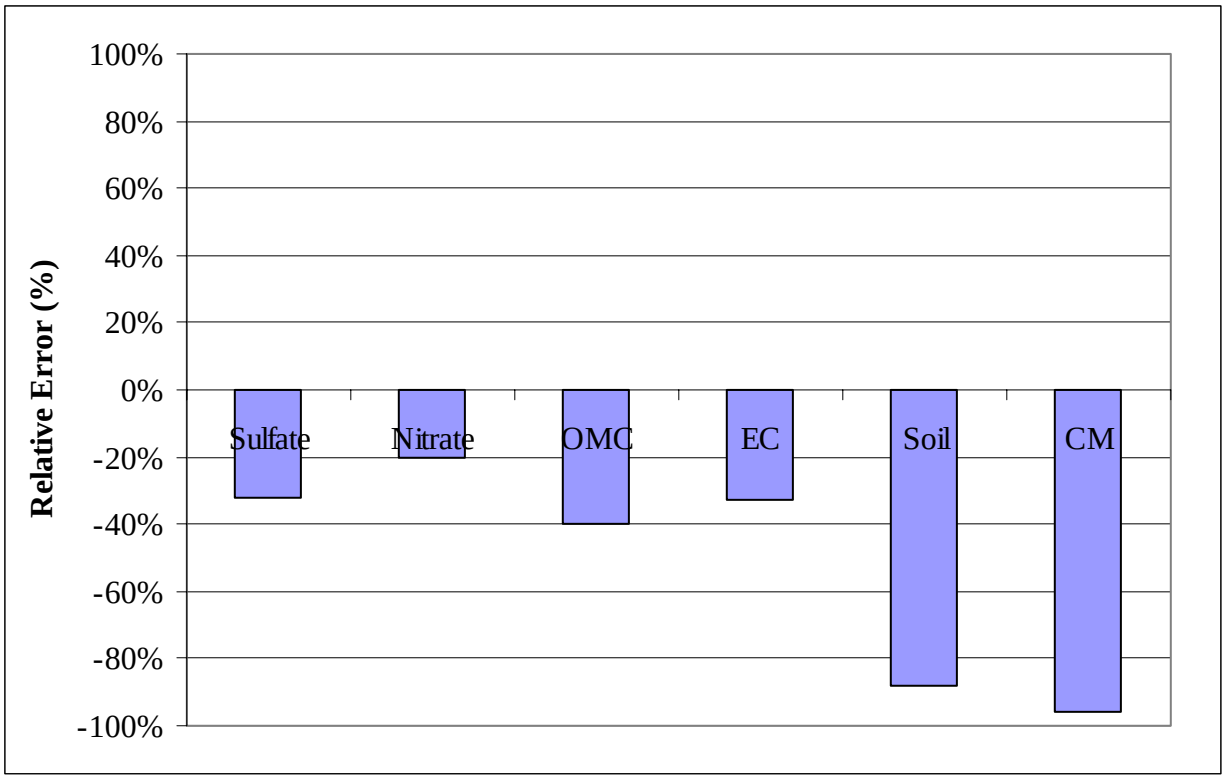


FIGURE 4-2

RELATIVE ERROR OF CMAQ MODEL PREDICTION VERSUS
IMPROVE DATA FOR JARB1 2002 WORST DAYS

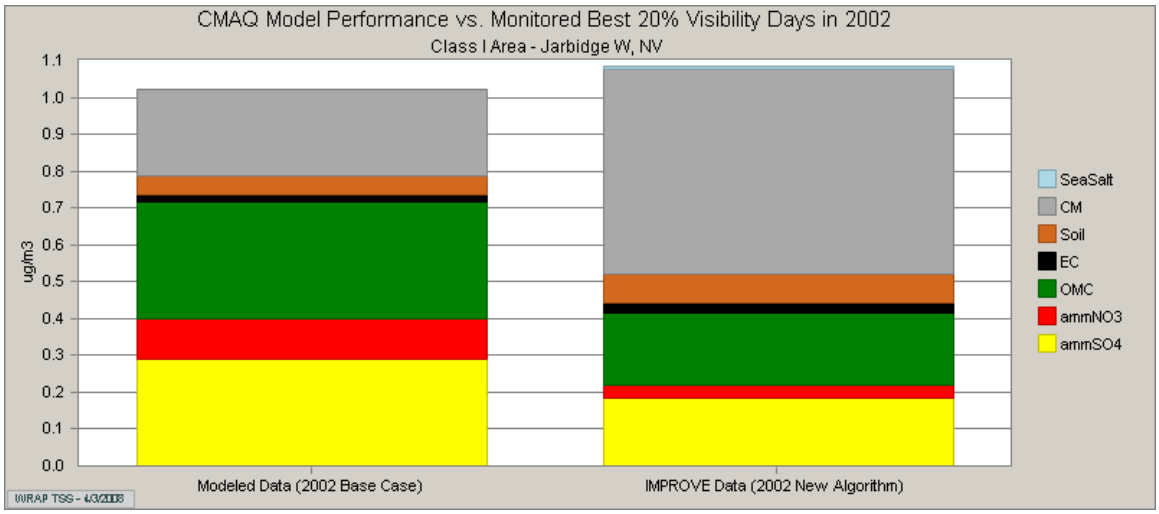


4.1.2.2 2002 Best Days Performance

Comparison of the model predicted concentration (left side of Figure 4-3) against the monitored concentration from the IMPROVE monitor JARB1 (right side of Figure 4-3) for the best days of 2002 shows much better agreement between total mass.

FIGURE 4-3

CMAQ MODEL PERFORMANCE FOR JARB1 2002 BEST DAYS



However, Figure 4-4 shows the model produces mixed predictions for the best days at JARB1. Nevada deems the model performance for the best days is acceptable for elemental carbon (-33 percent) and SOIL (-38 percent), but is marginally acceptable for sulfate (+61 percent) and organic matter (+60 percent). Model performance for nitrate (+175 percent) is unacceptable for the best days. As described above, RMC has concluded the CMAQ model cannot be used to predict future CM concentrations.

4.1.3 Weighted Emissions Potential Analysis

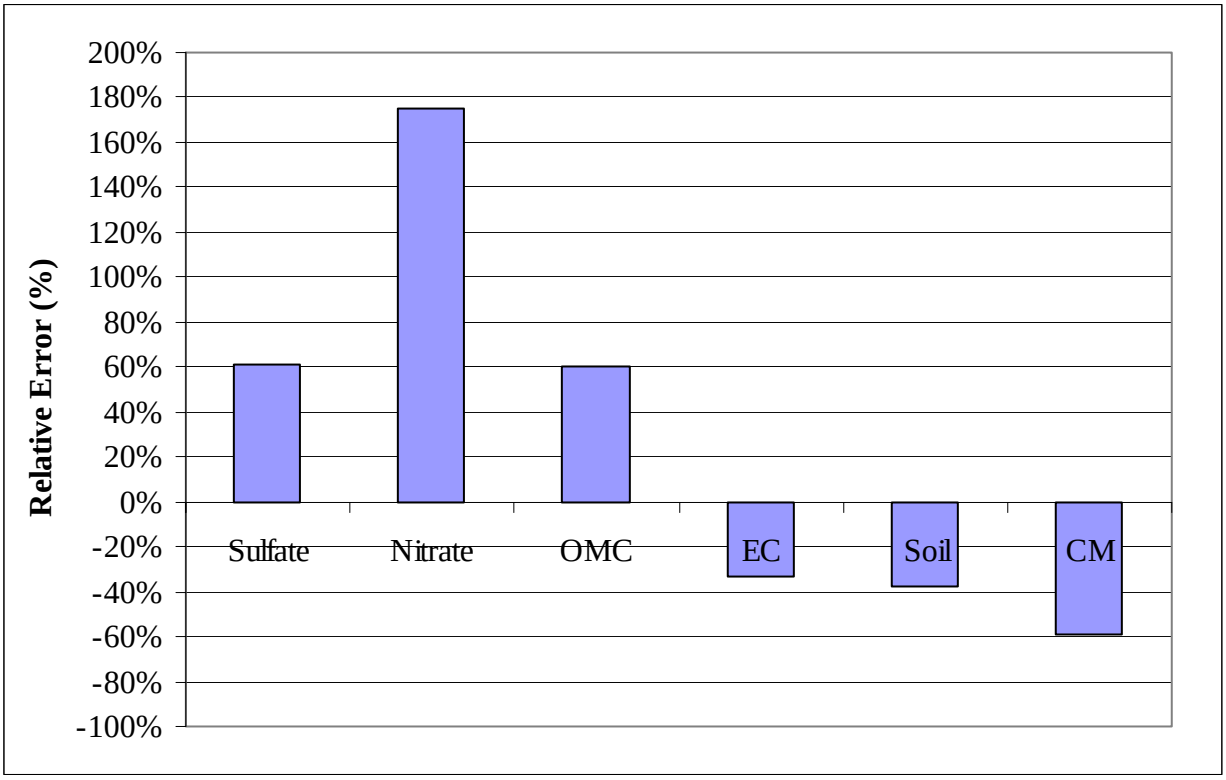
The WEP was developed as a screening tool for states to identify which source areas (e.g., states) have the potential to contribute to haze formation at specific Class I areas, based on both the 2002 and 2018 emissions inventories, as discussed in Chapter One. WEP was used to investigate the attribution of sources of nitrogen oxides (NO_x), sulfur dioxide (SO_2), organic carbon (OC), elemental carbon (EC), fine particulate matter (PMF) and coarse particulate matter (PMC). The results of the WEP analyses are discussed below in section 4.4.

4.2 VISIBILITY MODELING RESULTS FOR 2018

Visibility modeling results indicate projected visibility conditions for the Jarbidge WA, based on the PRP18a emission inventory, will meet the URP for 2018 (i.e., 2018 projected visibility conditions show better progress than the glidepath).

FIGURE 4-4

RELATIVE ERROR OF CMAQ MODEL PREDICTION VERSUS
IMPROVE DATA FOR JARB1 2002 BEST DAYS



4.2.1 2018 Visibility Projections for Jarbidge Wilderness Area

Table 4-1 lists the 2018 URP for the Jarbidge WA and the CMAQ visibility modeling forecasts for 2018. The results of this modeling will be used in establishing RPGs for the Jarbidge WA. The 2018 model forecasts indicate Jarbidge WA will meet the 2018 URP for the 20 percent worst days and will maintain visibility for the best days in 2018.

The 2018 modeling results of 11.05 deciviews (dv) presented in Table 4-1 and Figure 4-5 show an improvement of 1.02 dv from the worst days baseline value of 12.07 dv for the Jarbidge WA using the USEPA specific days method. This results in an improvement of 4.1 percent over the 2018 URP value of 11.09 dv, or 104.1 percent toward the 2018 URP. This indicates that Nevada's projected reasonable progress is better than the URP. The visibility model projections are based on the 2018 preliminary reasonable progress (PRP18a) emission inventory identified in Chapter Three. The 2018 PRP does not include all of Nevada's Best Available Retrofit Technology (BART) emission controls, or all of adjacent states' BART controls. Additional emission reductions due to the installation of BART and other controls under the RHR are anticipated to improve modeled visibility forecasts.

TABLE 4-1

SUMMARY OF MODEL-PREDICTED PROGRESS
TOWARD 2018 UNIFORM RATE OF PROGRESS AT JARB1

Mandatory Class I Federal Area	20 Percent Worst Days				20 Percent Best Days		
	Worst Days Baseline (dv)	2018 URP (dv)	2018 Modeling Results (dv)	CMAQ Modeling Percent Toward 2018 URP	Best Days Baseline (dv)	Average 2018 Modeling Results (dv)	CMAQ 2018 Modeling Result Less Than Baseline?
Jarbidge Wilderness Area	12.07	11.09	11.05	104.1%	2.56	2.50	Yes

FIGURE 4-5

CMAQ MODEL PROJECTIONS IN HAZE INDEX
FOR JARB1 2018 WORST DAYS

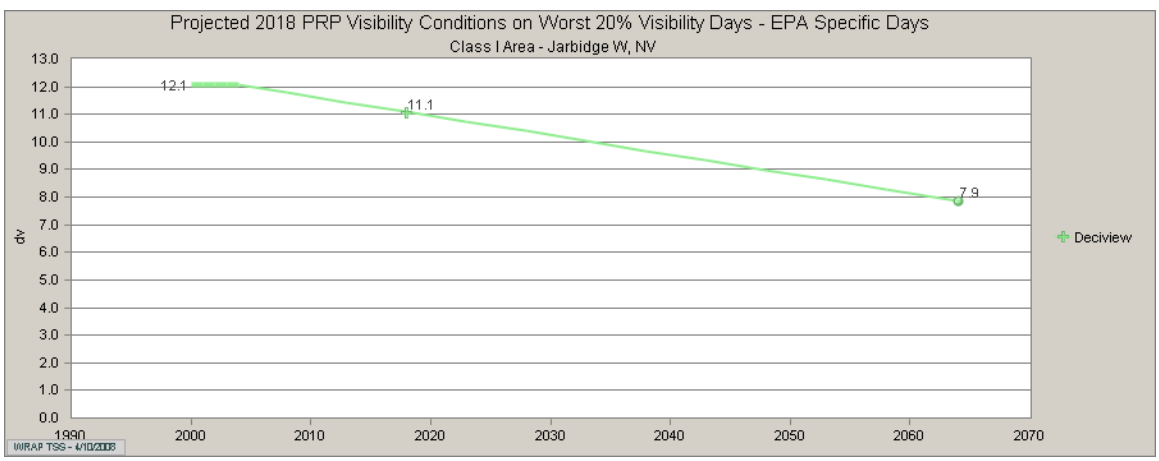


Figure 4-6 provides the species-specific extinction glide slopes in inverse megameters and corresponding 2018 model projections for the worst days at JARB1 using the USEPA specific days method. Table 4-2 presents these data graphically and identifies the 2018 URP, the model-projected 2018 extinction and the percentage of modeled progress from the baseline toward the 2018 URP. The values presented in Figures 4-5 and 4-6 are rounded to one decimal place, while those in Table 4-2 are presented to two decimal places.

All components show extinction reductions from baseline conditions, except CM and Sea Salt extinctions. These two remain constant from the baseline period to 2018 because the emission

inventories for these components were held constant for the baseline period and the 2018 projection for the purposes of modeling.

Projected 2018 extinction meets the URP for all components except SO_4 and Soil, as shown in Figure 4-6 and indicated by modeled extinction changes of greater than 100 percent in Table 4-2. The projected SO_4 extinction of 3.34 Mm^{-1} achieves 80 percent of the 2018 URP value (3.17 Mm^{-1}). The projected NO_3 extinction of 0.7 Mm^{-1} shows an improvement of 1000 percent toward the 2018 URP of 1.06 Mm^{-1}.

Recall that the RMC has indicated the CMAQ model cannot be used to forecast future CM concentrations, and NDEP has deemed the model performance for Soil on the worst days as unacceptable. The results for these species are presented for informational purposes.

FIGURE 4-6

CMAQ MODEL PROJECTIONS IN EXTINCTION
BY SPECIES FOR JARB1 2018 WORST DAYS

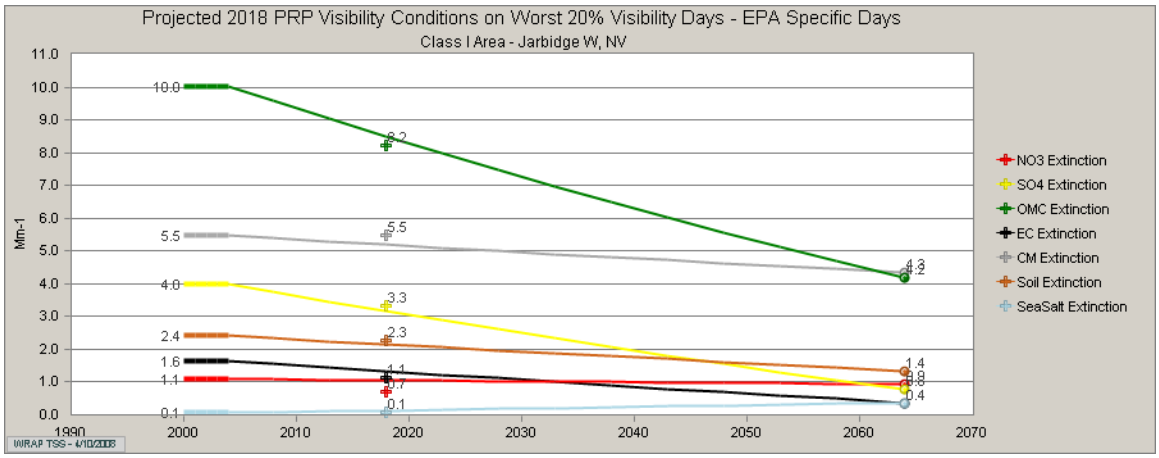


TABLE 4-2

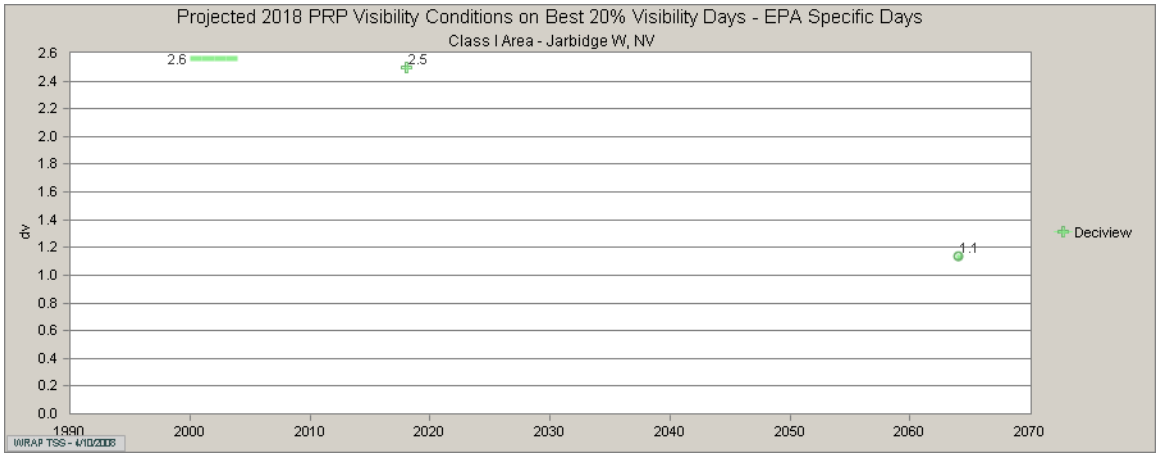
SUMMARY OF MODEL PREDICTED PROGRESS TOWARD
SPECIES-SPECIFIC 2018 WORST DAYS URP AT JARB1

Extinction (Mm^{-1})	Sulfate	Nitrate	Organic Carbon	Elemental Carbon	Fine Soil	Coarse Mass	Sea Salt
Baseline	4	1.1	10.04	1.65	2.41	5.47	0.06
2018 URP	3.17	1.06	8.49	1.34	2.15	5.2	0.13
Projected 2018 RP	3.34	0.7	8.24	1.12	2.29	5.47	0.06
Modeled Change from Baseline to 2018 URP (% of Goal)	80%	1000%	116%	171%	46%	0%	0%

Figure 4-7 indicates the 2018 model-projected extinction for the best days at JARB1, using the USEPA specific days method, is 2.50 dv, which is below the best days baseline average of 2.56 dv. These data indicate Nevada is forecast to maintain visibility for the best days of 2018 at the Jarbidge WA.

FIGURE 4-7

CMAQ MODEL PROJECTIONS IN HAZE INDEX FOR JARB1 2018 BEST DAYS



4.3 SOURCE APPORTIONMENT MODELING RESULTS

The PSAT algorithm in the CAMx model was developed to assess source apportionment. The PSAT analysis was used to attribute particle species, particularly sulfate and nitrate, from specific source areas and source categories, as discussed earlier. Emissions from each state or region for point, mobile, area and fire sources were tagged and tracked. The PSAT modeling utilized the Plan02c and Base18b emission inventories.

4.3.1 Sulfate Source Apportionment for Jarbidge Wilderness Area

Figure 4-8 displays the 2002 and 2018 worst days particulate sulfate concentrations impacting the JARB1 monitor due to emissions from WRAP states. The chart provides details on the relative source contribution for each WRAP state during 2002 and 2018. The data indicate the overall SO_2 emission sources for the worst days are from the states of Idaho, Oregon and Washington. Idaho's contributions to sulfate are primarily from natural fire emissions which were held constant from 2002 to 2018. Point sources also contribute significantly to sulfate from Idaho. Washington, Oregon, Nevada and California show contributions to sulfate primarily from point sources and natural fires.

Figure 4-9 shows the contributions to sulfate concentration from all modeled source areas for the worst days of 2002 and 2018 at the JARB1 monitor. These charts show that source areas outside the domain and within the WRAP region have sub-equal contributions of approximately 40 percent to year 2002 sulfate concentration at the JARB1 monitor for the worst days. Adding other source area contributions outside of the United States (i.e., Canada, Mexico and Pacific

Offshore) to the Outside Domain source area contributions suggests over 55 percent of the sulfate contributions to visibility impairment at the Jarbidge WA are outside the jurisdiction of state or federal regulation.

FIGURE 4-8

SULFATE PSAT SOURCE REGION BAR
CHART FOR WORST DAYS 2002 AND 2018

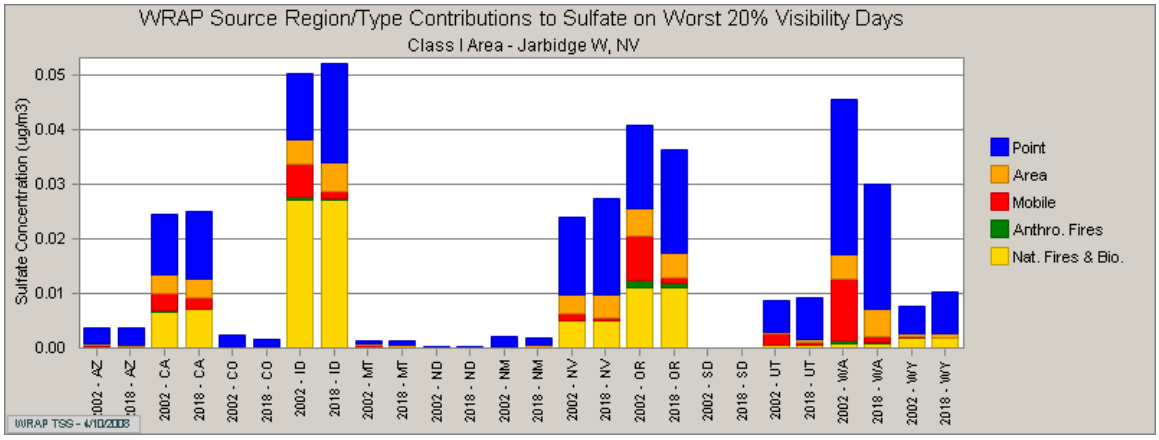


FIGURE 4-9

SULFATE PSAT REGIONAL PIE CHART FOR WORST DAYS 2002 AND 2018

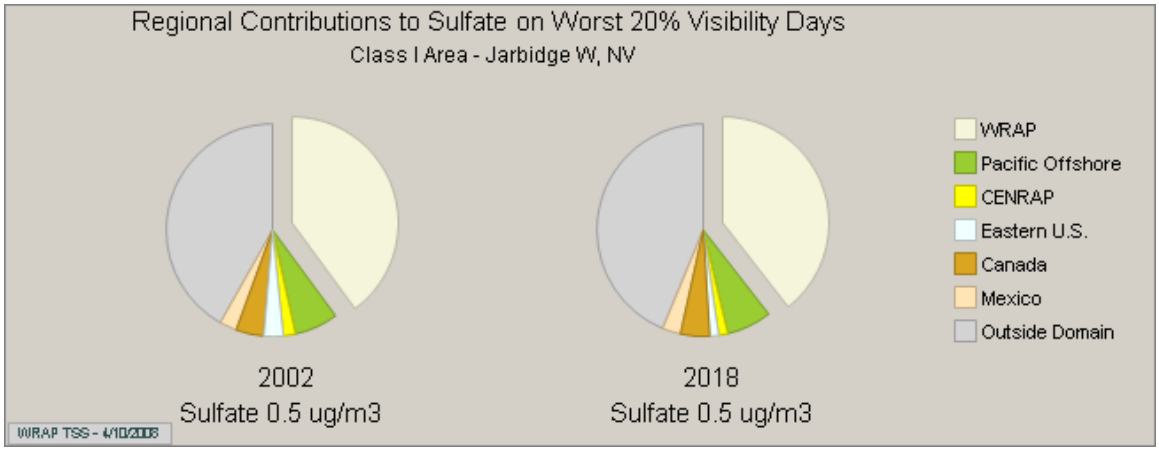


Figure 4-10 displays the 2002 and 2018 best days' particulate sulfate concentrations impacting the JARB1 monitor due to emissions from WRAP states. The chart provides details on the relative source contribution for each WRAP state during 2002 and 2018. The data indicate the dominant WRAP source area contribution for the best days is Nevada. Lesser contributions are due to emissions from Idaho, Oregon and California. Point sources are the dominant source category.

Figure 4-11 show the contributions to sulfate concentration from all modeled source areas for the best days of 2002 and 2018 at the JARB1 monitor. These charts show that WRAP source areas contribute less than a third to the sulfate concentration at the JARB1 monitor for the best days. Source areas outside the jurisdiction of state or federal regulation and/or control (i.e., Outside Domain, Canada, Mexico and Pacific Offshore) contribute more that two thirds to the sulfate concentration at the JARB1 monitor.

FIGURE 4-10

SULFATE PSAT SOURCE REGION BAR CHART FOR BEST DAYS 2002 AND 2018

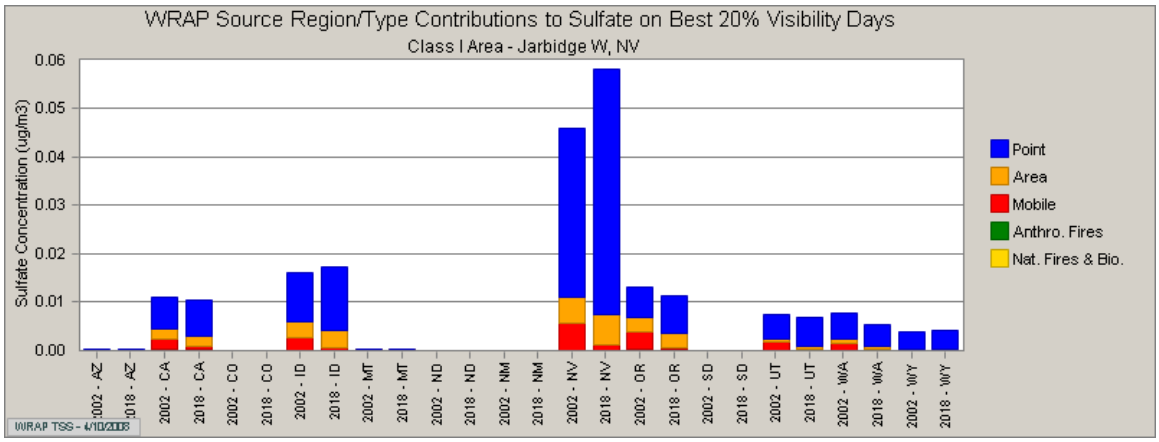
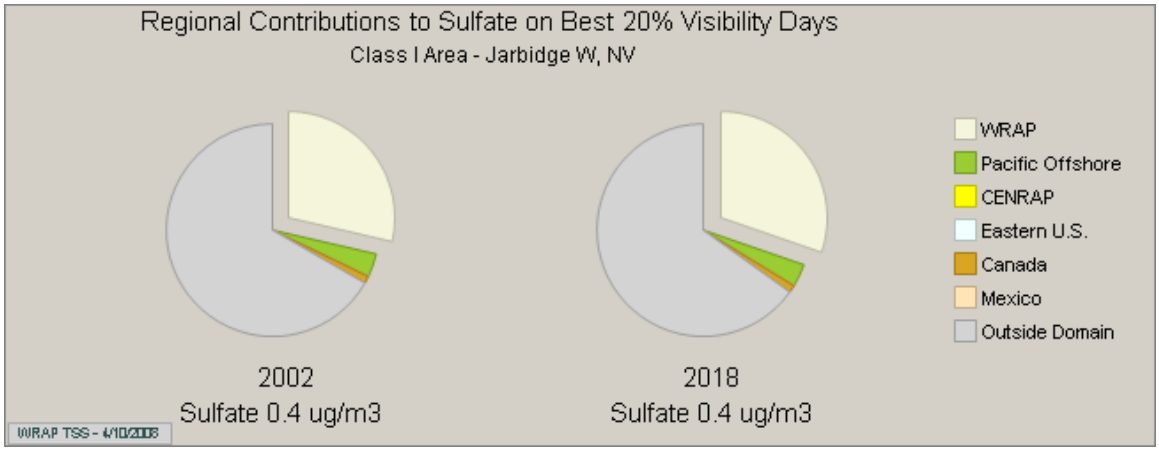


FIGURE 4-11

SULFATE PSAT REGIONAL PIE CHART FOR BEST DAYS 2002 AND 2018



4.3.2 Nitrate Source Apportionment for Jarbidge Wilderness Area

Figure 4-12 displays the particulate nitrate concentrations for 2002 and 2018 worst days for WRAP source areas at the JARB1 monitor. The chart provides details on the relative source contribution of each WRAP state during 2002 and 2018. The data indicate the dominant WRAP source area contributions for the worst days are from Idaho, Utah and Nevada. California,

Oregon and Washington had lesser contributions to nitrate concentrations at the JARB1 monitor. Mobile source emissions are the dominant source category for NO_x emissions, although area source emissions are significant for Idaho. Point source emissions from Idaho, Nevada and Utah are also important contributors to the modeled nitrate concentration for the worst days of 2002 and 2018.

FIGURE 4-12

NITRATE PSAT SOURCE REGION BAR CHART FOR WORST DAYS 2002 AND 2018

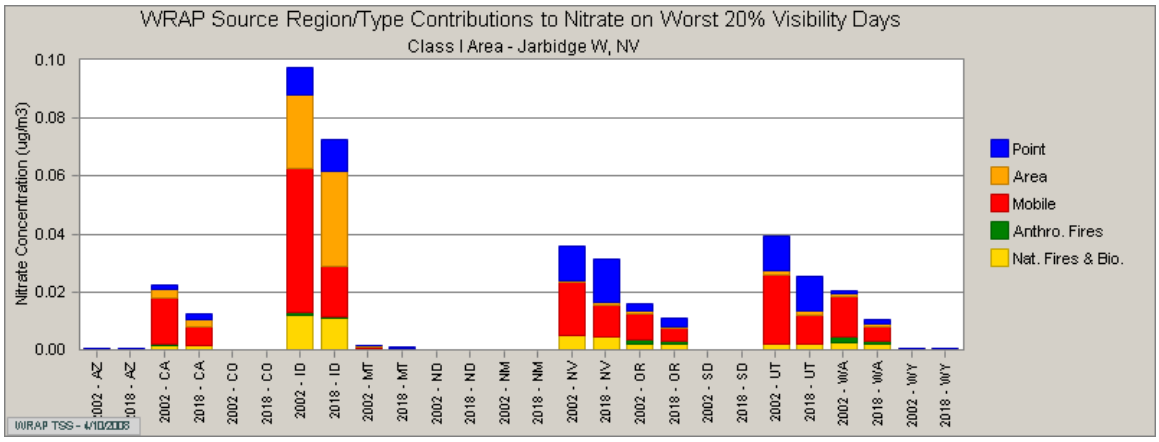


Figure 4-13 shows the contributions to nitrate concentration from all modeled source areas for the worst days of 2002 and 2018 at the JARB1 monitor. The pie charts show the WRAP region contributes more than three quarters to 2002 nitrate concentration at the JARB1 monitor for the worst days of 2002. The WRAP contribution drops to more than two thirds for 2018. Outside Domain sources combined with contributions from Mexico, Canada and Pacific Offshore areas contribute nearly a quarter to sulfate concentrations at the JARB1 monitor in 2002. Contributions from these sources increase to nearly a third for 2018.

FIGURE 4-13

NITRATE PSAT REGIONAL PIE CHART FOR WORST DAYS 2002 AND 2018

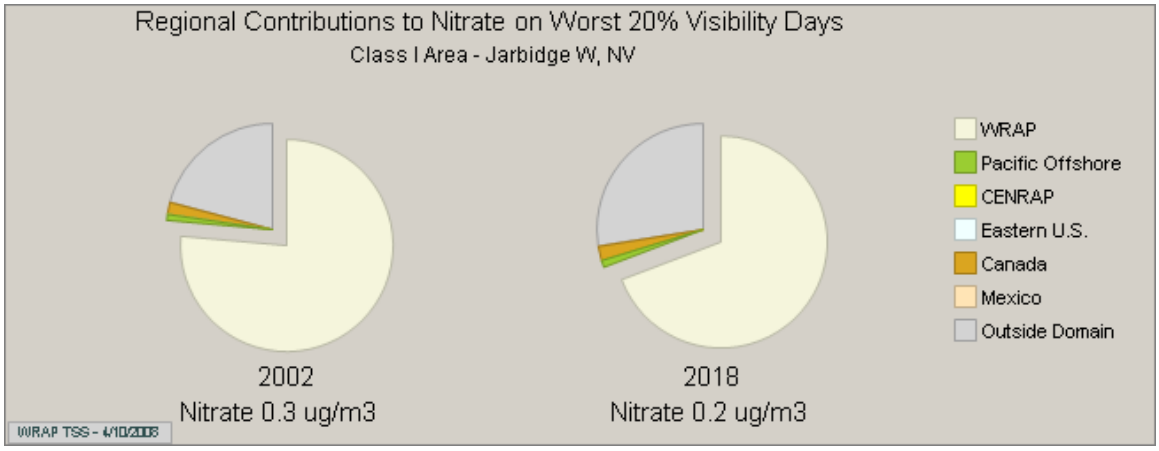


Figure 4-14 displays the 2002 and 2018 best days' particulate nitrate concentrations impacting the JARB1 monitor due to emissions from WRAP states. The chart provides details on the relative source contribution for each WRAP state during 2002 and 2018. The data indicate the dominant WRAP source area contribution for the best days is the State of Nevada with significant contributions from California and Idaho. Oregon, Utah and Washington show lesser contributions. Mobile sources are the dominant source category, except in Nevada, where point and mobile sources have sub-equal contribution to nitrate concentration at the JARB1 monitor. Area sources in Idaho also contribute significantly.

FIGURE 4-14

NITRATE PSAT SOURCE REGION BAR CHART FOR BEST DAYS 2002 AND 2018

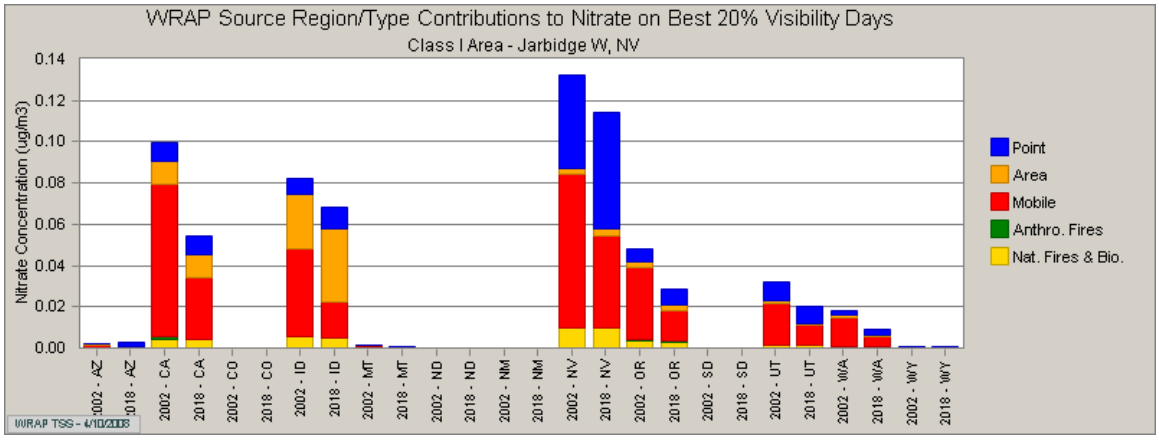
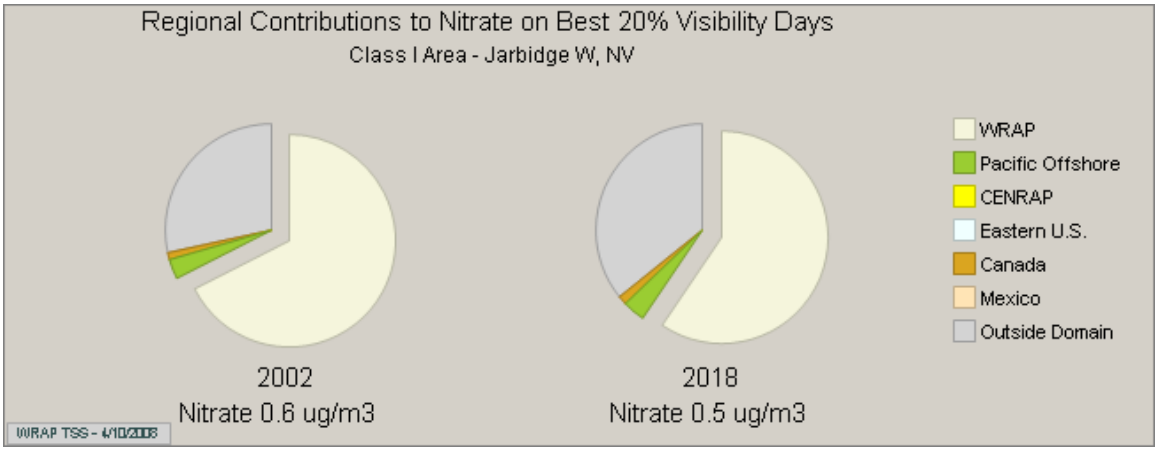


Figure 4-15 displays the contributions to nitrate concentration from all modeled source areas for 2002 and 2018 best days at JARB1. The pie charts indicate WRAP states contribute approximately two thirds to the nitrate concentration at the JARB1 monitor with the remaining nitrate impact due to Outside Domain, Canada and Pacific Offshore sources.

FIGURE 4-15

NITRATE PSAT REGIONAL PIE CHART FOR BEST DAYS 2002 AND 2018



4.3.3 Source Apportionment for Other Class I Areas

The PSAT source apportionment modeling results were evaluated to determine which Class I areas in adjacent states might be affected by emissions from Nevada sources. Table 4-3 presents the results of this evaluation for sulfate extinction. The table identifies the rank and percentage of the total modeled concentration due to SO_2 emissions from sources within Nevada to the IMPROVE monitors representing all Class I areas in the five adjacent states. The rank and percentage contribution is based on contributions from all modeled source areas. The bolded values are the highest percentage contribution to visibility impairment at Class I areas in each of the five adjacent states due to emissions from Nevada sources for the worst days projected for 2018.

Examination of the best days 2018 rank and contribution identifies the maximum contribution to sulfate extinction due to emissions from Nevada sources occurs at SAWT1 located in the Sawtooth Wilderness Area, with a rank of 4 and a contribution of 7.2 percent. For the worst days, Nevada's maximum contribution occurs at ZION1 located in Zion National Park with a rank of 6 and a contribution of 5.6 percent. Figure 4-16 shows SO_2 emissions from sources outside the modeling domain, which are beyond the jurisdiction of United States regulatory agencies and uncontrollable, contribute nearly eight times as much as Nevada sources to sulfate extinction on the 2018 best days at the Sawtooth Wilderness Area. Figure 4-17 shows the two source areas with the greatest contributions to sulfate extinction on the 2018 worst days to Zion National Park are Outside Domain and Pacific Offshore. Sources in Mexico are the fourth largest contributor while the majority of emissions from the third largest source area contributor are natural.

Table 4-4 presents the results of the source apportionment modeling for nitrate extinction at the Class I areas in adjacent states. Examination of the best days 2018 rank and contribution identifies the maximum contribution to nitrate extinction due to emissions from Nevada sources

occurs at JOSH1 located in Joshua Tree National Park, with a rank of 4 and a contribution of 12.4 percent. For the worst days, Nevada's maximum contribution occurs at BLIS1 located in Bliss State Park (monitor location for Desolation Wilderness Area and Mokelumne Wilderness Area) with a rank of 3 and a contribution of 20.0 percent. The bolded values in this table represent the maximum visibility impacts at the Class I areas in adjacent states due to Nevada's emissions for the worst days projected for 2018.

TABLE 4-3

NEVADA'S SULFATE EXTINCTION CONTRIBUTION TO
CLASS I AREAS OUTSIDE OF NEVADA

IMPROVE Site Code	IMPROVE Site Name	Sulfate Extinction Contribution due to Nevada Emissions							
		Best Days				Worst Days			
		2002		2018		2002		2018	
		Impact	Rank	Impact	Rank	Impact	Rank	Impact	Rank
Arizona									
GRCA2	Hance Camp	3.1%	4	2.8%	5	6.0%	6	**2.8%**	6
IKBA1	Ike's Backbone	4.2%	6	2.6%	8	3.3%	8	1.5%	10
SIAN1	Sierra Ancha	2.6%	9	1.6%	9	3.1%	8	1.5%	9
SYCA1	Sycamore Canyon	6.3%	3	3.1%	6	5.6%	6	2.5%	8
TONT1	Tonto	2.2%	7	1.3%	9	2.7%	8	1.3%	9
California									
BLIS1	Bliss State Park	3.0%	4	3.1%	4	4.8%	5	**4.4%**	5
DOME1	Dome Lands	6.3%	3	5.3%	3	2.0%	7	1.6%	8
HOOV1	Hoover	2.3%	4	2.2%	4	3.0%	6	2.6%	6
JOSH1	Joshua Tree	6.6%	4	4.0%	4	1.7%	6	1.2%	6
KAIS1	Kaiser	1.6%	4	1.5%	4	2.9%	6	2.4%	6
LAVO1	Lassen Volcanic	2.7%	4	3.0%	4	2.1%	7	2.3%	7
LABE1	Lava Beds	3.5%	4	3.8%	4	3.1%	7	3.2%	7
SAGA1	San Gabriel	2.4%	4	2.0%	4	1.0%	7	0.7%	8
SAGO1	San Gorgonio	6.9%	4	4.1%	5	1.5%	6	0.9%	6
SEQU1	Sequoia	3.1%	4	2.2%	5	2.8%	5	2.0%	5
YOSE1	Yosemite	2.9%	6	2.4%	7	1.9%	4	1.6%	4
Idaho									
CRMO1	Craters of the Moon	3.5%	7	4.1%	6	1.6%	9	1.9%	9
SAWT1	Sawtooth	5.9%	5	7.2%	4	2.2%	8	**2.5%**	8
Oregon									
CRLA1	Crater Lake	0.8%	7	0.8%	7	1.2%	7	1.4%	7
HECA1	Hells Canyon	1.2%	8	1.6%	5	3.2%	7	**4.0%**	6
STAR1	Starkey	1.6%	7	1.9%	7	1.7%	7	2.0%	7
Utah									
BRCA1	Bryce Canyon	3.8%	3	4.1%	4	8.1%	5	4.8%	6
CAPI1	Capitol Reef	2.4%	8	2.5%	8	6.0%	6	3.9%	6
ZION1	Zion	5.4%	3	4.9%	3	9.0%	4	**5.6%**	6

FIGURE 4-16

SULFATE PSAT SOURCE REGION BAR CHART FOR BEST DAYS
2002 AND 2018 AT SAWTOOTH WILDERNESS AREA

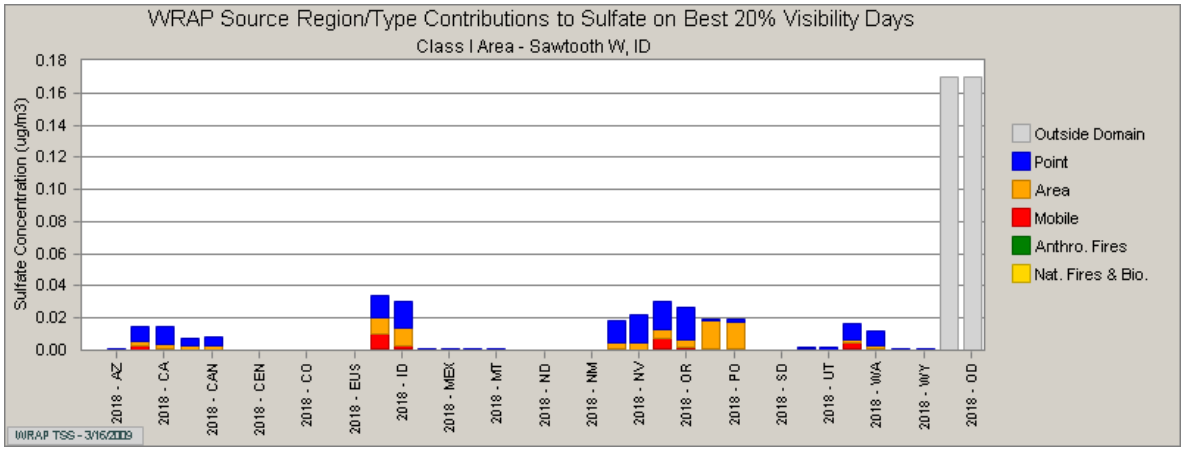


FIGURE 4-17

SULFATE PSAT SOURCE REGION BAR CHART FOR WORST DAYS
2002 AND 2018 AT ZION NATIONAL PARK

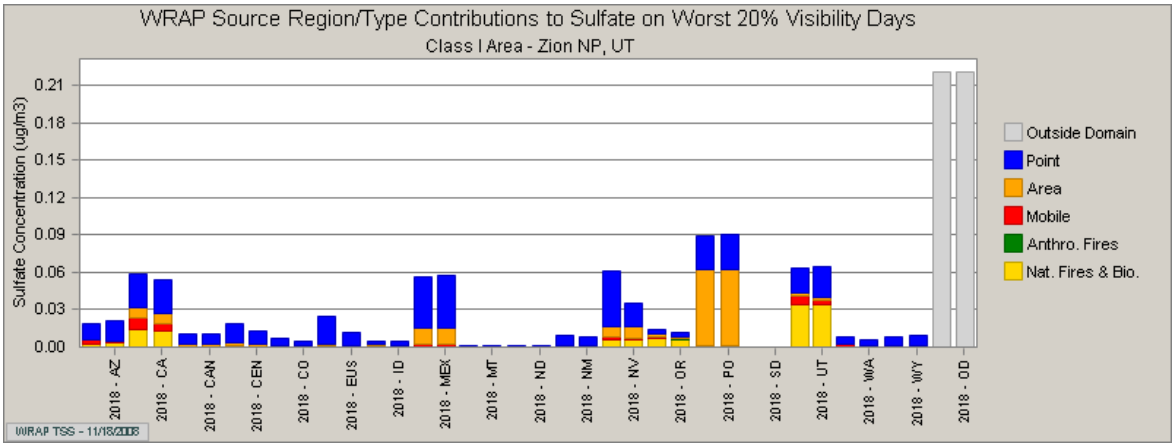


Figure 4-18 shows NO_x emissions from California sources are the dominant contributor to nitrate extinction on the 2018 best days at Joshua Tree National Park, followed by sources outside the modeling domain and Pacific offshore sources. Figure 4-19 shows NO_x emissions from California sources are the dominant contributor for the 2018 worst days, followed by emissions from sources outside the modeling domain to nitrate extinction at the Desolation Wilderness Area.

TABLE 4-4

NEVADA'S NITRATE EXTINCTION CONTRIBUTION TO
CLASS I AREAS OUTSIDE OF NEVADA

IMPROVE Site Code	IMPROVE Site Name	Nitrate Extinction Contribution due to Nevada Emissions							
		Best Days				Worst Days			
		2002		2018		2002		2018	
		Impact	Rank	Impact	Rank	Impact	Rank	Impact	Rank
Arizona									
GRCA2	Hance Camp	5.8%	5	5.8%	5	2.2%	6	2.8%	6
IKBA1	Ike's Backbone	2.8%	6	3.2%	6	1.6%	8	2.4%	8
SIAN1	Sierra Ancha	2.3%	7	2.7%	7	2.6%	5	3.9%	5
SYCA1	Sycamore Canyon	3.4%	6	4.3%	6	3.4%	6	**4.3%**	6
TONT1	Tonto	2.4%	6	2.7%	6	1.5%	7	2.1%	7
California									
BLIS1	Bliss State Park	4.2%	4	4.9%	4	16.3%	3	**20.0%**	3
DOME1	Dome Lands	8.6%	3	9.6%	3	1.8%	4	2.3%	4
HOOV1	Hoover	4.3%	3	4.8%	3	7.7%	3	8.3%	3
JOSH1	Joshua Tree	11.0%	4	12.4%	4	0.6%	4	0.6%	4
KAIS1	Kaiser	2.3%	4	2.7%	4	2.9%	6	4.0%	4
LAVO1	Lassen Volcanic	3.6%	4	4.8%	4	2.4%	6	3.0%	5
LABE1	Lava Beds	3.7%	5	4.4%	5	6.6%	4	8.0%	4
SAGA1	San Gabriel	2.0%	4	2.4%	4	0.3%	6	0.4%	5
SAGO1	San Gorgonio	5.4%	4	6.4%	4	0.3%	5	0.5%	5
SEQU1	Sequoia	2.7%	4	3.6%	4	1.6%	4	2.0%	4
YOSE1	Yosemite	1.8%	4	2.2%	4	3.8%	4	5.1%	4
Idaho									
CRMO1	Craters of the Moon	5.8%	8	6.6%	5	2.3%	9	2.7%	8
SAWT1	Sawtooth	6.5%	5	7.5%	5	3.1%	7	**3.2%**	6
Oregon									
CRLA1	Crater Lake	1.2%	6	1.5%	7	1.6%	7	2.0%	7
HECA1	Hells Canyon	2.0%	8	2.4%	8	4.8%	6	**5.5%**	5
STAR1	Starkey	3.2%	6	3.7%	6	3.7%	7	4.5%	6
Utah									
BRCA1	Bryce Canyon	4.0%	4	4.0%	5	8.8%	4	**8.8%**	4
CAPI1	Capitol Reef	2.9%	5	2.9%	6	5.2%	4	5.4%	5
ZION1	Zion	6.2%	4	6.2%	5	8.1%	4	7.9%	4

FIGURE 4-18

NITRATE PSAT SOURCE REGION BAR CHART FOR BEST DAYS
2002 AND 2018 AT JOSHUA TREE NATIONAL PARK

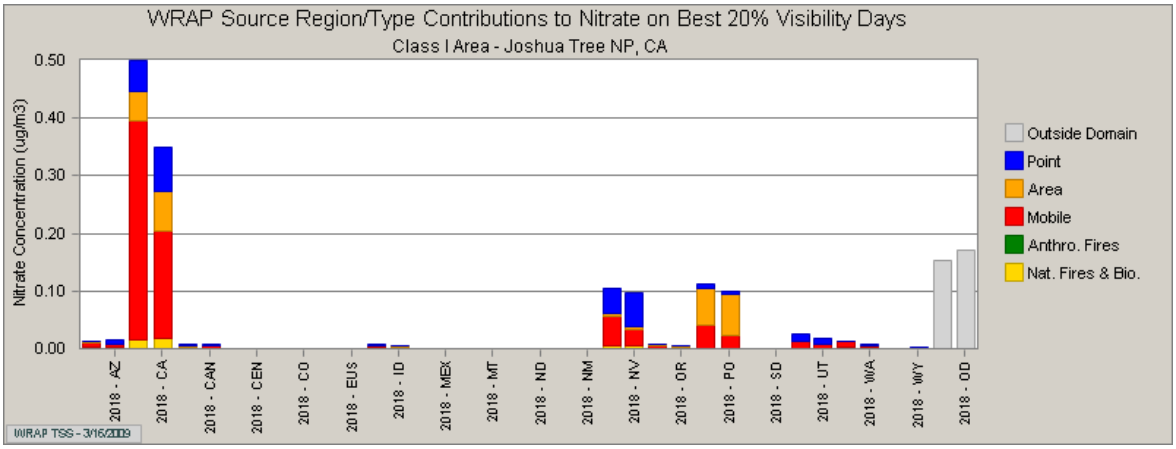
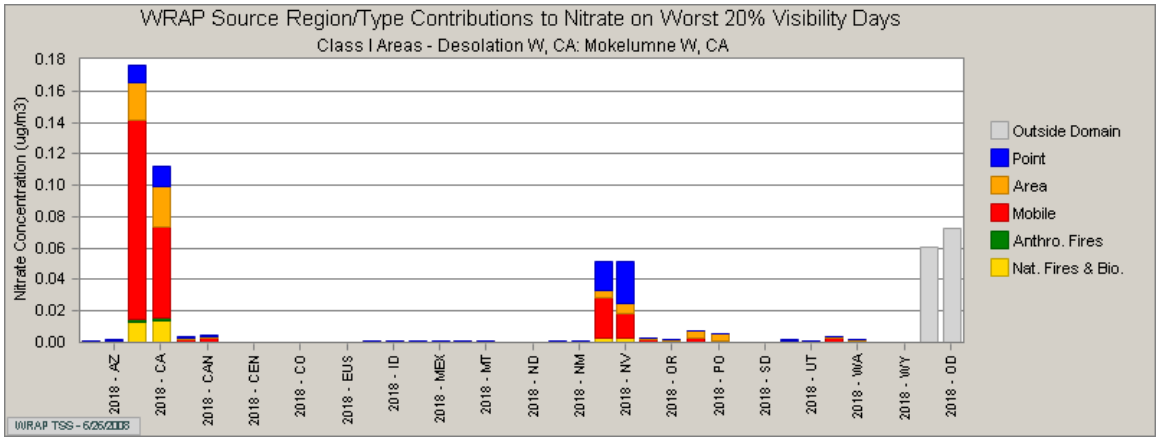


FIGURE 4-19

NITRATE PSAT SOURCE REGION BAR CHART FOR WORST DAYS
2002 AND 2018 AT DESOLATION WILDERNESS AREA



4.3.4 Organic Aerosol Source Apportionment for Jarbidge Wilderness Area

The PSAT algorithm was also used in a limited application to track natural and anthropogenic species of organic aerosols at each Class I area. Source area (e.g., no state or regional) attribution was not performed for the aerosol source apportionment. The organic aerosol tracer tracked both POA and SOA. POAs are primary organics resulting form direct organic aerosol emissions from anthropogenic and biogenic sources. SOAs are further subdivided to include anthropogenic secondary organics resulting form aromatic VOCs such as xylene, toluene and cresols, as well as biogenic secondary organics resulting from biogenic VOCs such as terpenes. The purpose of the organic aerosol tracer tool is to investigate the contribution of primary and secondary anthropogenic and biogenic sources on modeled OC at Class I areas.

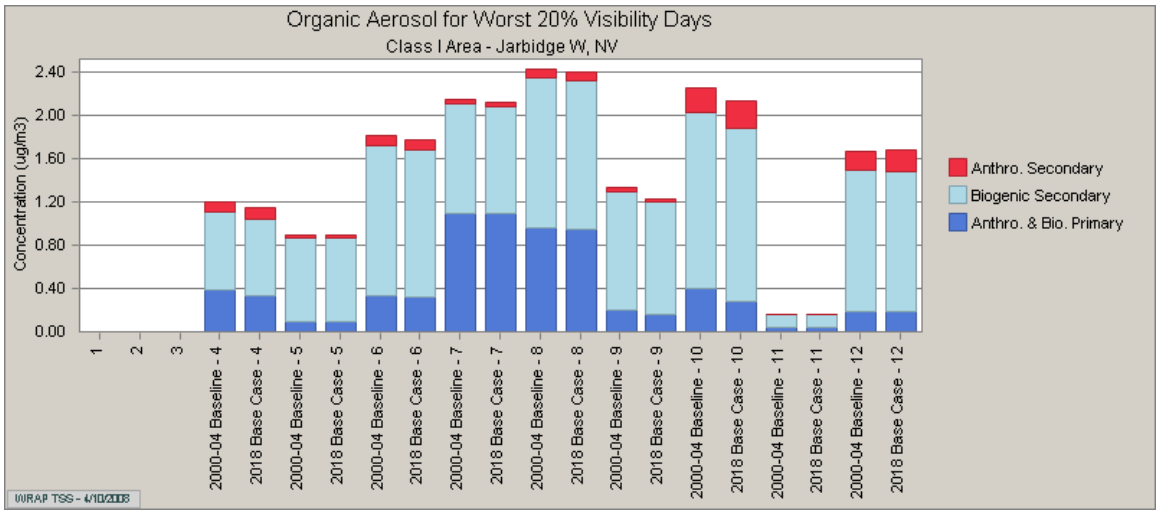
A wide variety of sources contribute to POAs, from cooking of meat to diesel emissions and combustion byproducts from wood and agricultural burning (e.g., emissions from area sources, on-road and off-road mobile sources, fugitive dust sources and fire sources). Nevada's POA emissions inventory is dominated by natural fire emissions as described in Chapter 3 (see 3.8.4) and shown in Figure 3-17 and Table 3-10.

4.3.4.1 Organic Aerosol PSAT for Worst Days 2002 and 2018

Figure 4-20 displays the monthly organic aerosol concentration for the baseline period (2000 through 2004) and 2018 in pairs for the worst days at the JARB1 monitor. The organic aerosol PSAT tracks anthropogenic SOA (in red), biogenic SOA (in sky blue) and anthropogenic/biogenic POA (in blue). The chart provides details on the relative anthropogenic and biogenic concentration for each month of the baseline period and the future contribution in 2018. None of the worst days for the baseline period or for 2018 occurred during the winter or early spring months of January, February or March.

FIGURE 4-20

MONTHLY ORGANIC AEROSOL PSAT BAR CHART FOR
WORST DAYS 2002 AND 2018

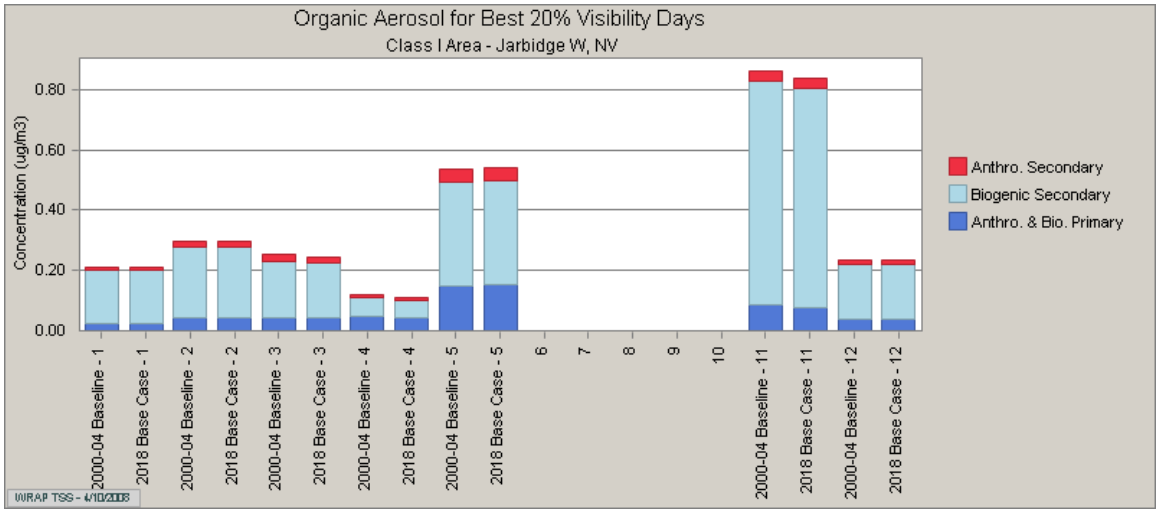


4.3.4.2 Organic Aerosol PSAT for Best Days 2002 and 2018

Figure 4-21 displays the monthly organic aerosol concentration for the baseline period (2000 through 2004) and 2018 for the best days at the JARB1 monitor. None of the best days during the baseline period or for 2018 occurred in the summer or early fall months of June, July, August, September or October.

FIGURE 4-21

MONTHLY ORGANIC AEROSOL PSAT BAR CHART FOR BEST DAYS 2002 AND 2018



4.3.4.3 Organic Aerosol PSAT for All Days 2002 and 2018

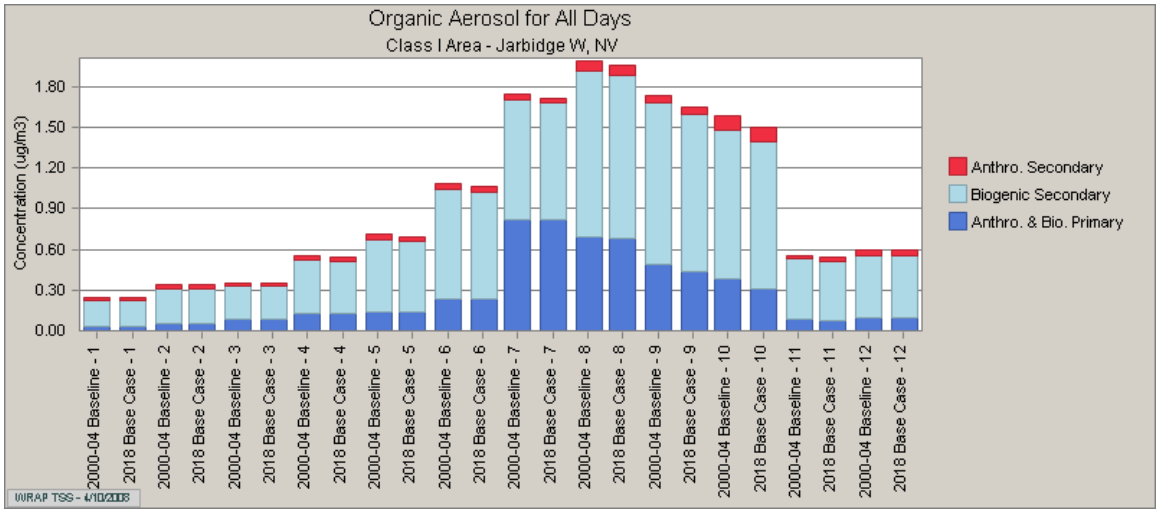
Figure 4-22 displays the monthly organic aerosol concentrations for the baseline period (2000 through 2004) and 2018 for all days at the JARB1 monitor. This figure shows the strong seasonal influence of biogenic and fire emissions on visibility at the Jarbidge WA. The bar chart indicates biogenic SOA (in sky blue) is the dominant source of organic aerosol for all months of the year and it occurs at much higher concentrations during the summer and early fall months of June, July, August, September and October when temperatures are warmer and vegetative growth is most prolific. Significant POA concentrations are indicative of the contribution of natural fire emissions occurring in the months of July, August, September and to a lesser degree October.

4.4 WEIGHTED EMISSIONS POTENTIAL ANALYSES RESULTS

The Weighted Emissions Potential (WEP) tool is an analysis technique that identifies the predominant emission source regions contributing haze-forming pollutants at each Class I area based on 5 years of historical meteorology for both the 20 percent best and worst days, as described in Chapter One.

FIGURE 4-22

ORGANIC AEROSOL PSAT BAR CHART FOR ALL DAYS 2002 AND 2018



The WEP analysis results in two graphical displays of the data: WEP maps of normalized, weighted emissions; and WEP bar charts of normalized, residence time- and distance-weighted annual emissions. The maps show the location of the Jarbidge WA with a green star surrounded by 100 km and 200 km radius concentric circles. The areas shaded in different colors identify those 36 km grid cells with the potential of contributing emissions to JARB1 for the worst days in 2018. Geographical regions and individual grid cells with greater potential to impact the Jarbidge WA are easily distinguished in the maps by the darker shaded grid cells, while the white areas denote those grid cells with negligible emission potential.

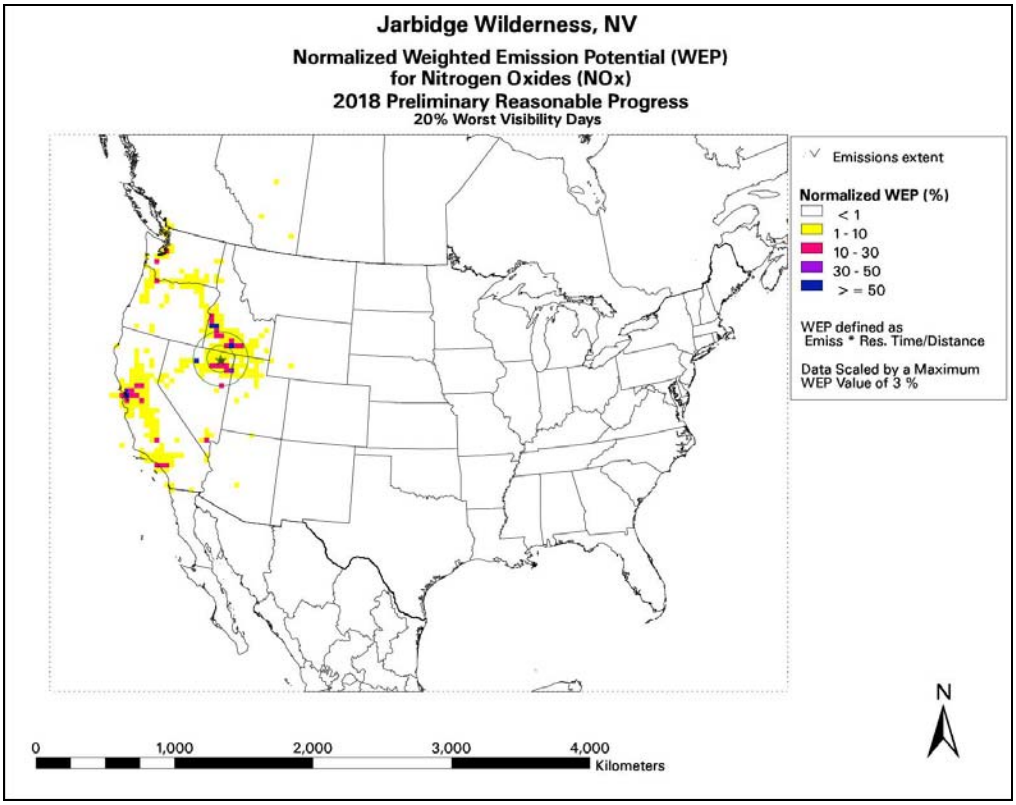
Geographic source areas and source categories are also easily distinguished on the bar charts, which identify twelve source categories: windblown dust, fugitive dust, road dust, off-road mobile, on-road mobile, off-shore, oil and gas, area, biogenic, natural fire, anthropogenic fire and point. Two different modeling simulation emission scenarios (using the Plan02d and PRP18a emission inventories) were used to produce the WEP maps. Only the PRP18a emission scenario maps for the worst days are presented below.

4.4.1 Nitrogen Oxides – Regional WEP Analysis for 2018 Worst Days

Figure 4-23 shows the normalized regional contributions to residence time- and distance-weighted NO_x emissions for JARB1. The WEP bar charts, shown as Figure 4-24, display normalized (unitless), residence time- and distance-weighted 2018 annual NO_x emissions values, by emissions source region.

FIGURE 4-23

REGIONAL NO_x WEP FOR 2018 WORST DAYS



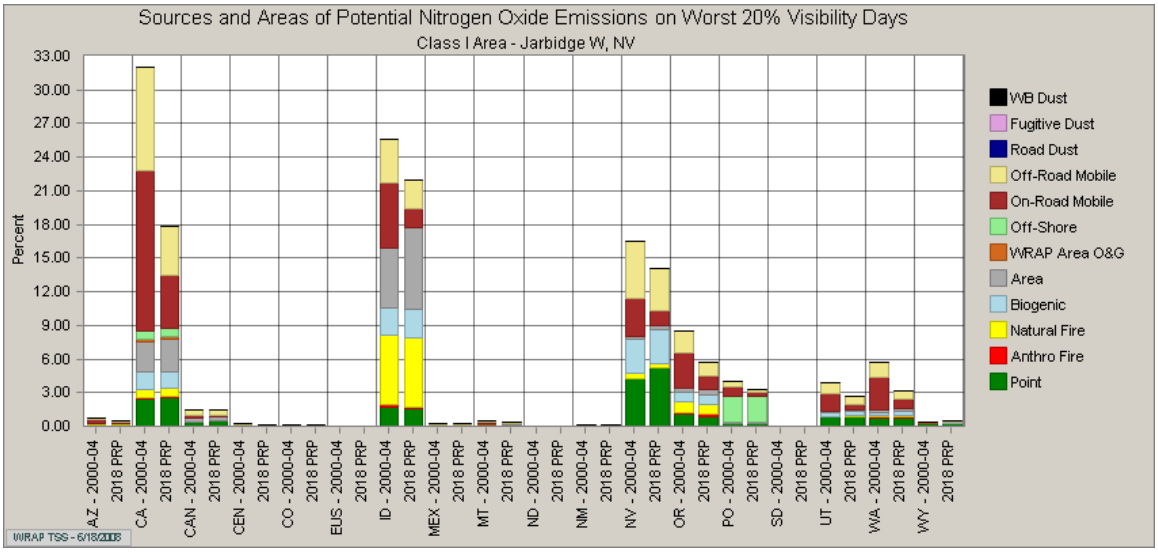
Examination of Figures 4-23 and 4-24 shows the point source contributions from the industrialized portions of northern Nevada and along the Snake River Plain of Idaho, as well as more distance areas in southern Nevada and portions of California, including the Bay Area, Central Valley and Los Angeles area to 2018 NO_x concentration at JARB1. These figures also show the contribution of mobile sources, both on-road and off-road, from the main transportation corridors and population centers along I-80 in Nevada and Utah, I-84 in Utah, Idaho, and Oregon, and I-5 in California to NO_x emissions at JARB1.

4.4.2 Sulfur Oxides – Regional WEP Analysis for 2018 Worst Days

Figure 4-25 shows the normalized regional contributions to residence time- and distance-weighted SO_2 emissions for JARB1. The WEP bar charts, shown as Figure 4-26, display normalized (unitless), residence time- and distance-weighted annual SO_2 emissions values, by emissions source region. Examination of Figures 4-25 and 4-26 shows the large point source contributions from the industrialized portions of northeastern Nevada and along the Snake River Plain of Idaho, as well as more distance areas in the Bay Area of California to 2018 SO_2 concentration at JARB1. These figures also show the contribution of natural fires in Idaho to SO_2 emissions at JARB1.

FIGURE 4-24

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING NO_x
EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS



4.4.3 Organic Carbon – Regional WEP Analysis for 2018 Worst Days

Figure 4-27 shows the normalized regional contributions to residence time- and distance-weighted organic carbon (POA) emissions for JARB1. The WEP bar charts, shown as Figure 4-28, display normalized (unitless), residence time- and distance-weighted annual OC emissions values, by emissions source region. Examination of Figures 4-27 and 4-28 shows the large, natural fire source contributions from diffuse areas of California, Idaho, northern Nevada, Oregon, Utah and Washington to 2018 OC concentration at JARB1. These figures also show the contribution of area sources from population centers along the Snake River Plain of Idaho, the Central Valley and Bay Area of California, the Portland area of Oregon and the Seattle area of Washington.

4.4.4 Elemental Carbon – Regional WEP Analysis for 2018 Worst Days

Figure 4-29 shows the normalized regional contributions to residence time- and distance-weighted primary EC emissions for JARB1. The WEP bar charts, shown as Figure 4-30, display normalized (unitless), residence time- and distance-weighted annual primary EC emissions values, by emissions source region. The contribution distribution shown by EC is very similar to that shown by OC. Examination of Figures 4-29 and 4-30 shows the large, natural fire-source contributions from diffuse areas of California, Idaho, northern Nevada, Oregon, Utah and Washington to 2018 EC concentration at JARB1. Figure 3-22 in Chapter Three more clearly shows that the EC emissions in Nevada are primarily due to natural fire events. These figures also show the contribution of area and off-road mobile sources from population centers along the Snake River Plain of Idaho, the Central Valley and Bay Area of California, the Portland area of Oregon and the Seattle area of Washington.

FIGURE 4-25

REGIONAL SO_2 WEP FOR 2018 WORST DAYS

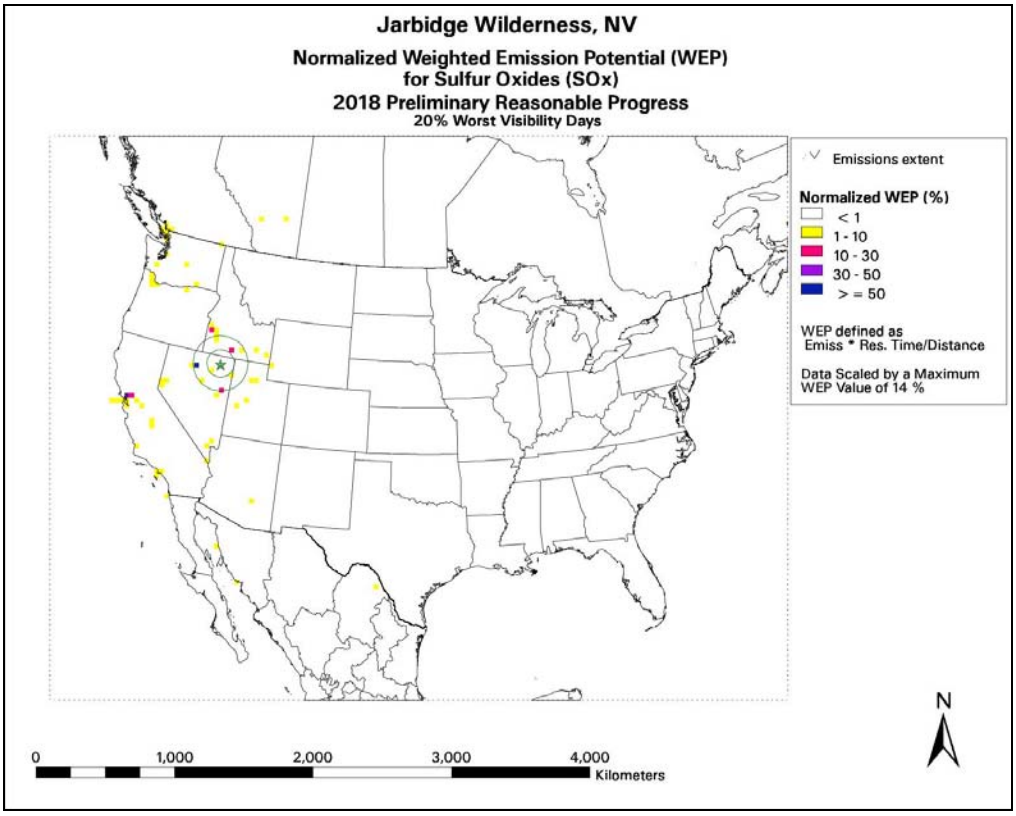


FIGURE 4-26

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING SO_2 EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS

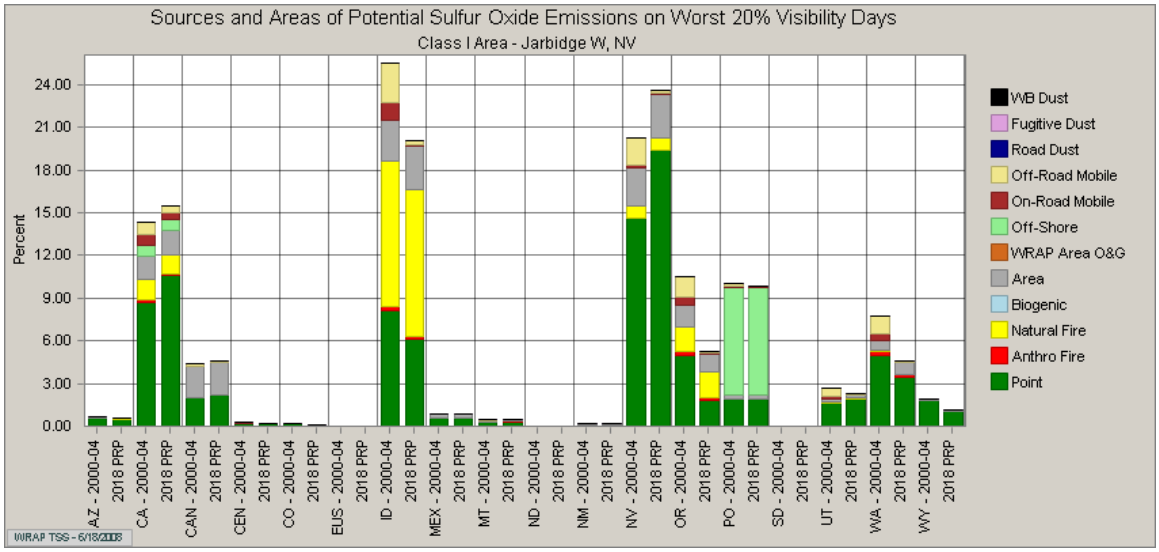


FIGURE 4-27

REGIONAL ORGANIC CARBON WEP FOR 2018 WORST DAYS

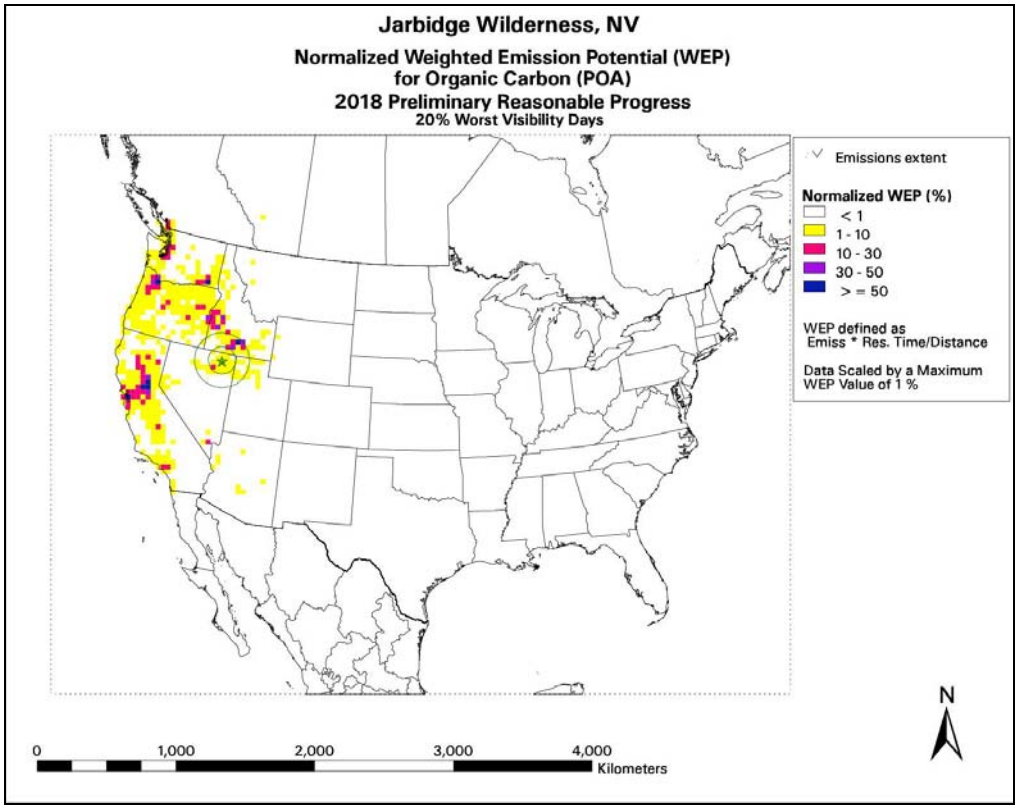


FIGURE 4-28

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING ORGANIC CARBON EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS

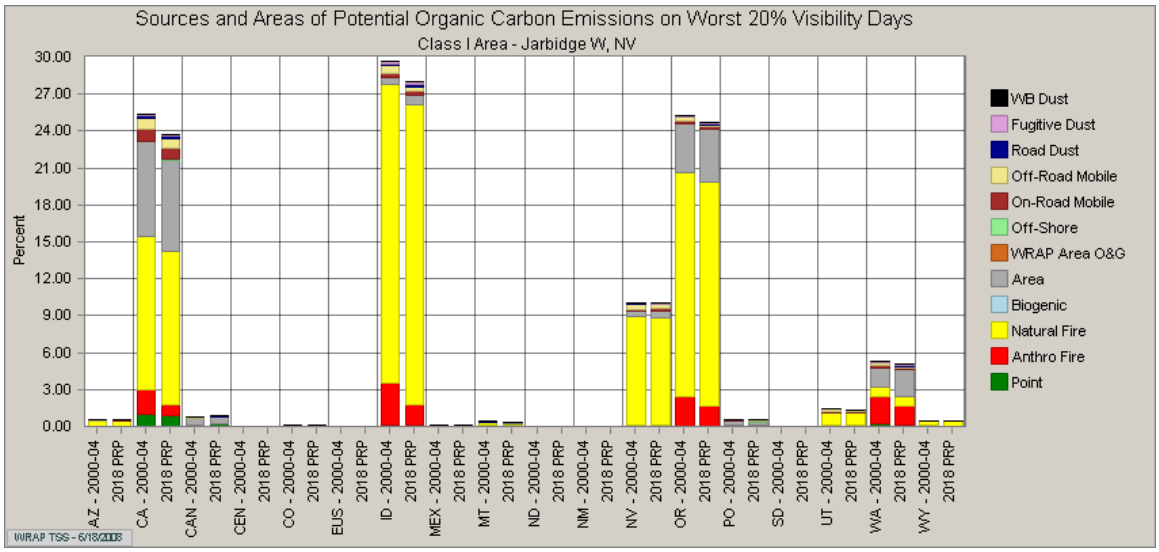


FIGURE 4-29

REGIONAL ELEMENTAL CARBON WEP FOR 2018 WORST DAYS

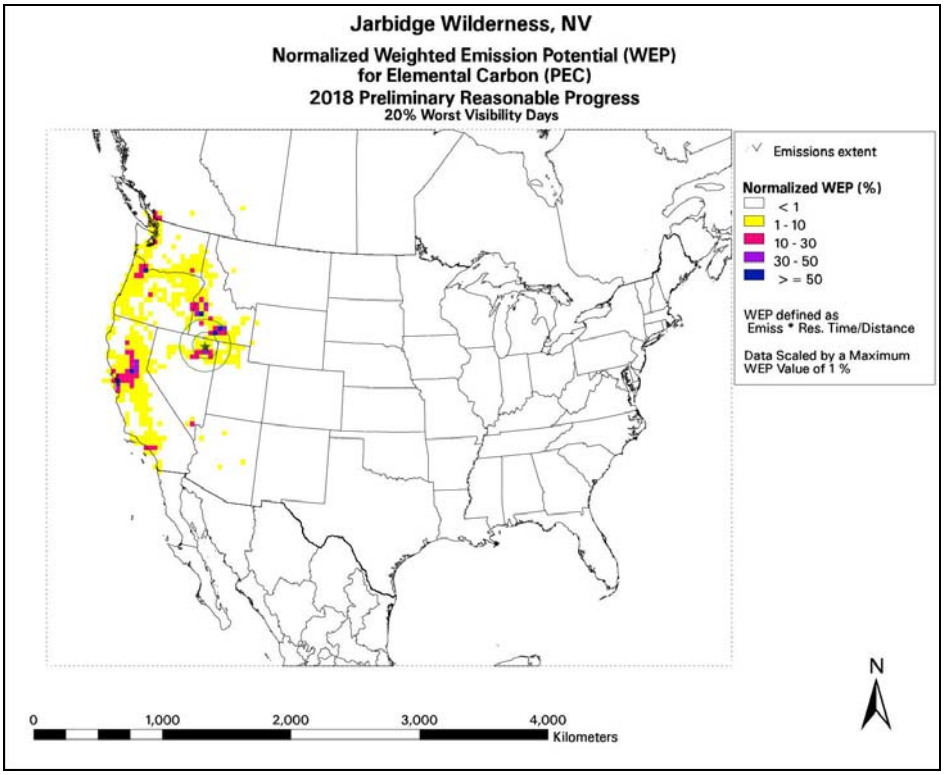
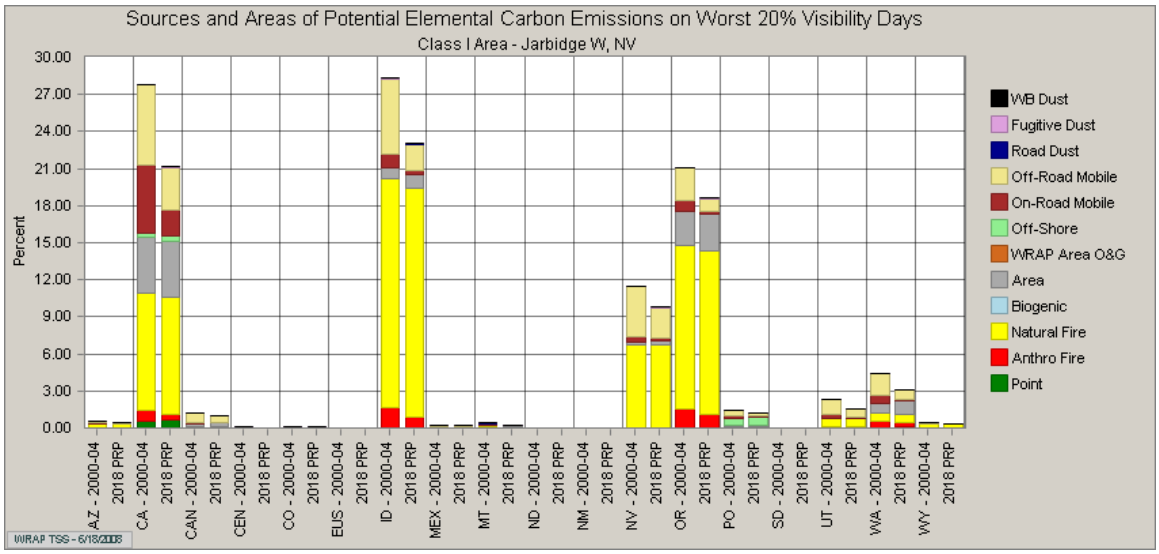


FIGURE 4-30

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING ELEMENTAL CARBON EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS



4.4.5 Particulate Matter Fine – Regional WEP Analysis for 2018 Worst Days

Figure 4-31 shows the normalized regional contributions to residence time- and distance-weighted PMF emissions for JARB1. The WEP bar charts, shown as Figure 4-32, display normalized (unitless), residence time- and distance-weighted annual PMF emissions values, by emissions source region.

Examination of Figures 4-31 and 4-32 shows the large windblown dust-source contributions from diffuse areas of southern Idaho, northern Nevada, eastern Oregon and northern Utah to 2018 PMF concentration at JARB1. These figures also show lesser fugitive dust contributions from the same diffuse areas of Idaho, Nevada, Oregon and Washington, as well as the contribution of area sources from population centers along the Snake River Plain of Idaho, the Central Valley and Bay Area of California, and the Portland area of Oregon.

FIGURE 4-31

REGIONAL PARTICULATE MATTER FINE WEP FOR 2018 WORST DAYS

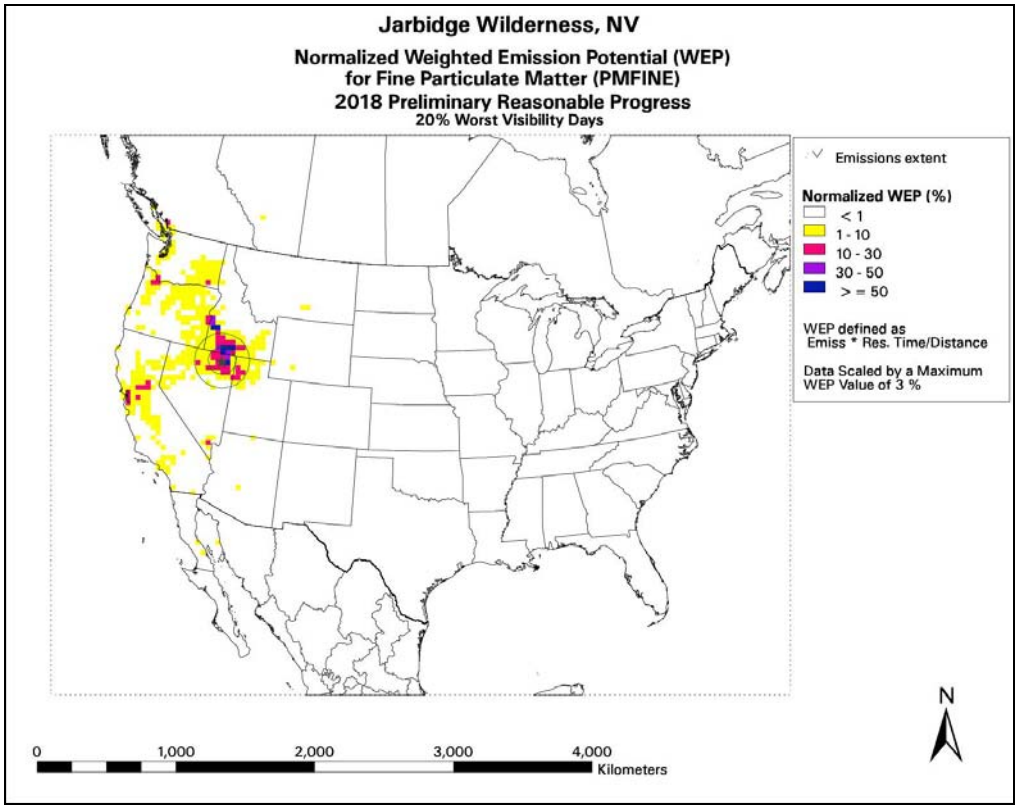
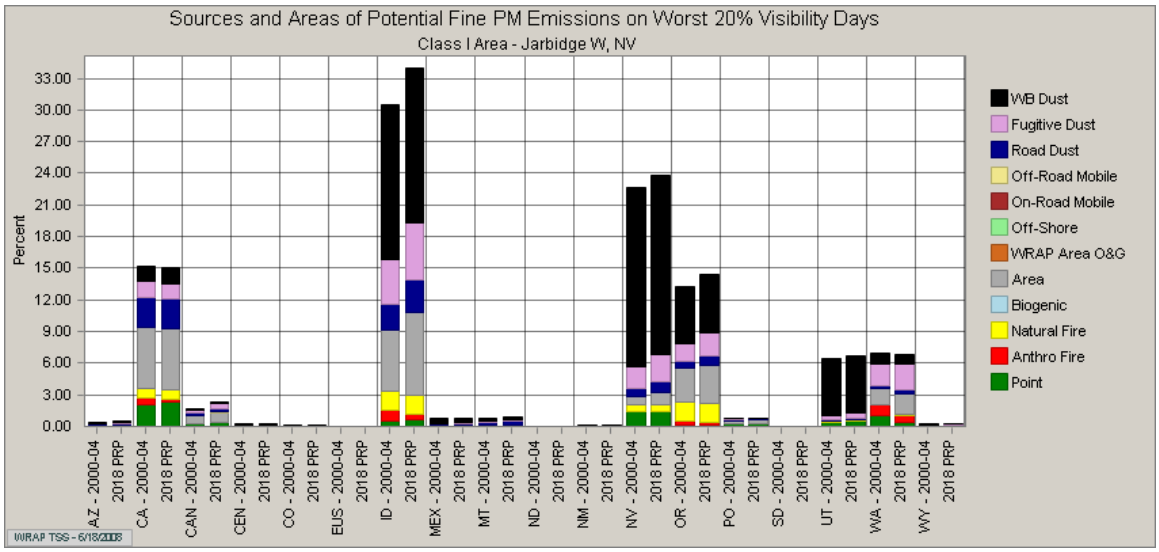


FIGURE 4-32

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING PARTICULATE MATTER FINE EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS



4.4.6 Particulate Matter Coarse – Regional WEP Analysis for 2018 Worst Days

Figure 4-33 shows the normalized regional contributions to residence time- and distance-weighted PMC emissions for JARB1. The WEP bar charts, shown as Figure 4-34, display normalized (unitless), residence time- and distance-weighted annual PMC emissions values, by emissions source region. The contribution distribution shown by PMC is very similar to that shown by PMF. Examination of Figures 4-33 and 4-34 shows the large windblown dust source contributions from diffuse areas of southern Idaho, northern Nevada, eastern Oregon and northern Utah to 2018 PMF concentration at JARB1. These figures also show lesser fugitive dust contributions from the same diffuse areas of Idaho, Nevada, Oregon and Washington, as well as the contribution of area sources from population centers along the Snake River Plain of Idaho, the Central Valley and Bay Area of California, and the Portland area of Oregon. Road dust is an important contributor from areas of California and Idaho.

FIGURE 4-33

REGIONAL PARTICULATE MATTER COARSE WEP FOR 2018 WORST DAYS

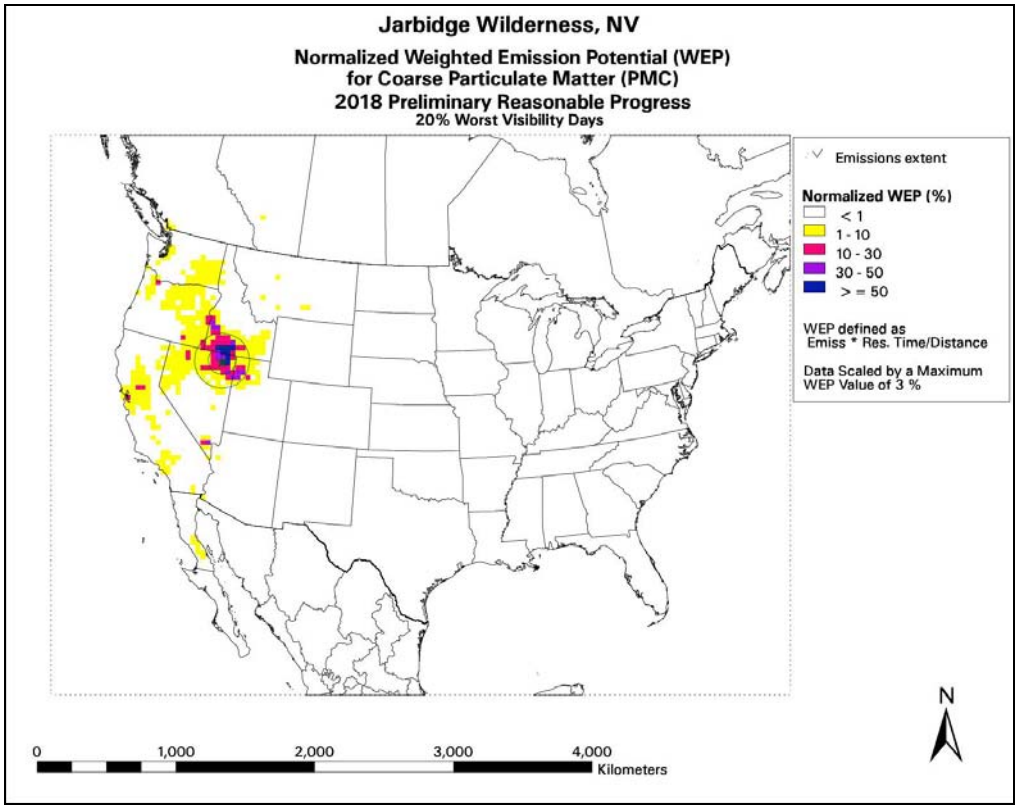
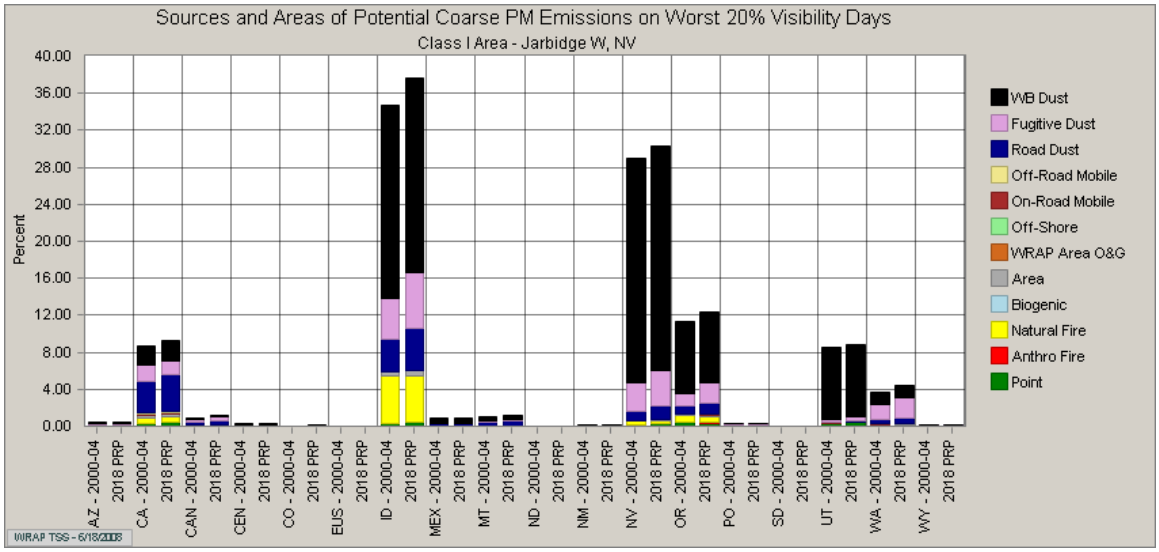


FIGURE 4-34

SOURCES AND AREAS OF POTENTIAL HAZE-CAUSING PARTICULATE MATTER COARSE EMISSIONS FOR JARB1 2002 AND 2018 WORST DAYS



4.5 VISIBILITY AND SOURCE APPORTIONMENT MODELING SUMMARY

Results of the CMAQ visibility modeling forecasts indicate the Jarbidge WA will meet the URP for 2018 for the worst days with no degradation of best days.

Results of the PSAT source apportionment modeling identify the source areas contributing to sulfate and nitrate extinction at the JARB1 monitor. Table 4-5 lists the four source areas with the highest contribution of SO_2 and NO_x to JARB1 based on the source apportionment modeling. The area with the greatest sulfate contribution is Outside Domain (or boundary conditions), which has contributions four times greater than any other source area. Point, area and natural fire sources all contribute approximately one-third to visibility impairment at the Jarbidge WA. Nevada is not a significant contributor of sulfate at the Jarbidge WA.

Idaho, closely followed by Outside Domain, is the largest source area contributor to nitrate at JARB1. Nevada and Utah also contribute significantly to modeled nitrate concentrations in the Jarbidge WA. Point, mobile and area sources contribute subequally to nitrate, with a lesser contribution from natural fire sources.

Boundary conditions represent the background concentrations of pollutants that enter the edge of the modeling domain. Emissions can be transported great distances and represent international emissions beyond the portions of Canada and Mexico that lie within the modeling domain. Boundary conditions represent emissions from sources beyond the jurisdiction of United States regulatory agencies and are uncontrollable for the purposes of Nevada's regional haze SIP.

TABLE 4-5

SUMMARY OF 2018 MODEL RESULTS FOR JARBIDGE WILDERNESS AREA

2018 Sulfate PSAT - 20% Worst Days 4 Regions with Greatest Contribution to Jarbidge					2018 Nitrate PSAT - 20% Worst Days 4 Regions with Greatest Contribution to Jarbidge				
Sources*	1st	2nd	3rd	4th	Sources*	1st	2nd	3rd	4th
	Outside Domain	Idaho	Oregon	Pacific Offshore		Idaho	Outside Domain	Nevada	Utah
	43.8%	10.3%	7.2%	6.9%		30.3%	27.5%	13.1%	10.6%

* Outside Domain not included in pie charts

Point Sources
Mobile Sources
Natural Fire Sources
Area Sources

Table 4-6 lists the 2002 to 2018 change in modeled particulate sulfate and nitrate concentrations at the Jarbidge WA for the worst days. The 2018 PSAT modeling forecasts overall decreases in total sulfate and nitrate concentrations (i.e., "Total SO_4" and "Total NO_3" columns of Table 4-6) at the JARB1 monitor. However, the modeled contributions to sulfate at JARB1 due to Nevada sources (NV SO_4 column) increased by 14 percent, while modeled nitrate contributions due to Nevada sources (NV NO_3 column) decreased by 12 percent. The PSAT modeling used the Plan02c and Base18b emission inventories, as discussed in Chapter One.

TABLE 4-6

CHANGE IN WORST DAYS MODELED CONCENTRATIONS
OF SULFATE AND NITRATE

Class I Area	Year	Total SO_4 (ug/m^3)	NV SO_4 (ug/m^3)	NV Share SO_4	NV [SO_4] Change	Total NO_3 (ug/m^3)	NV NO_3 (ug/m^3)	NV Share NO_3	NV [NO_3] Change
Jarbidge Wilderness Area	2002	0.529	0.0241	4.6%		0.308	0.0358	11.6%	
	2018	0.507	0.0275	5.4%	+14%	0.240	0.0314	13.1%	-12%

Figure 4-35 summarizes the Nevada Plan02c and Base18b SO_2 inventories, while Figure 4-36 summarizes the Nevada Plan02d and PRP18a SO_2 inventories. Figures 4-37 and 4-38 summarize the same data for NO_x.

FIGURE 4-35

NEVADA SO_2 PLAN02c AND BASE18b
EMISSION INVENTORY COMPARISON

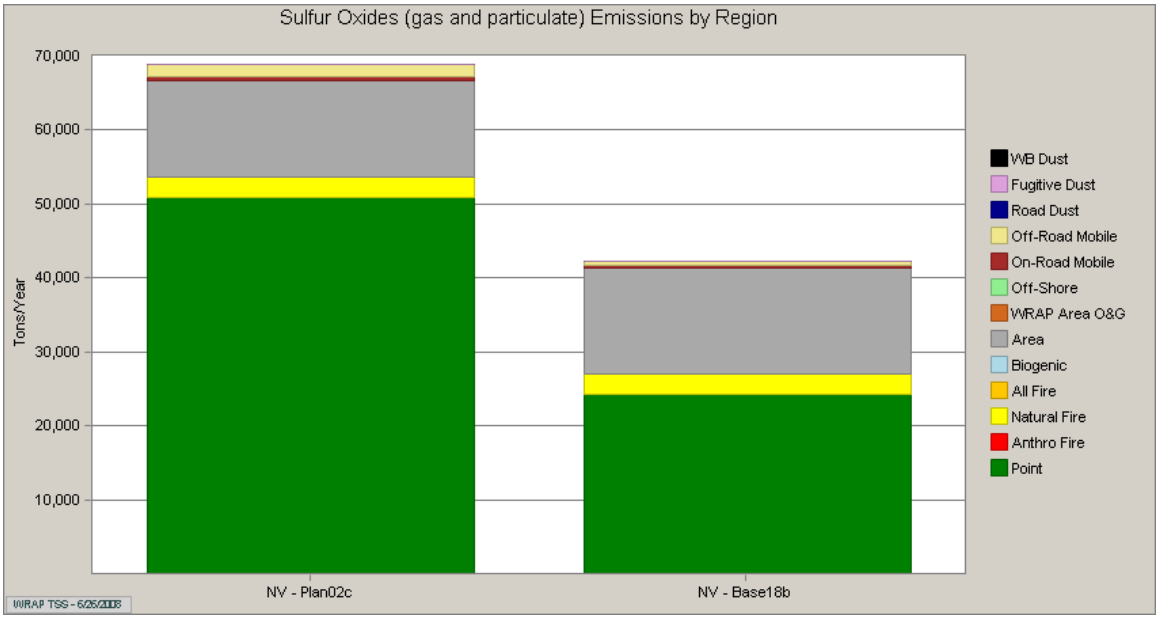


FIGURE 4-36

NEVADA SO_2 PLAN02d AND PRP18a
EMISSION INVENTORY COMPARISON

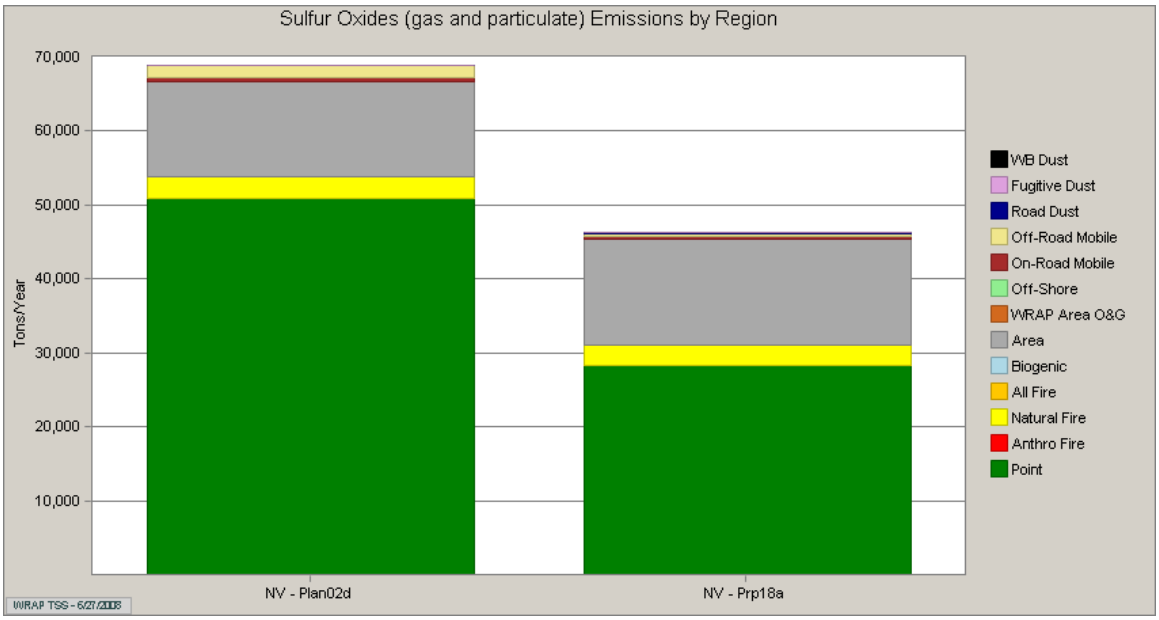


FIGURE 4-37

NEVADA NO_x PLAN02c AND BASE18b
EMISSION INVENTORY COMPARISON

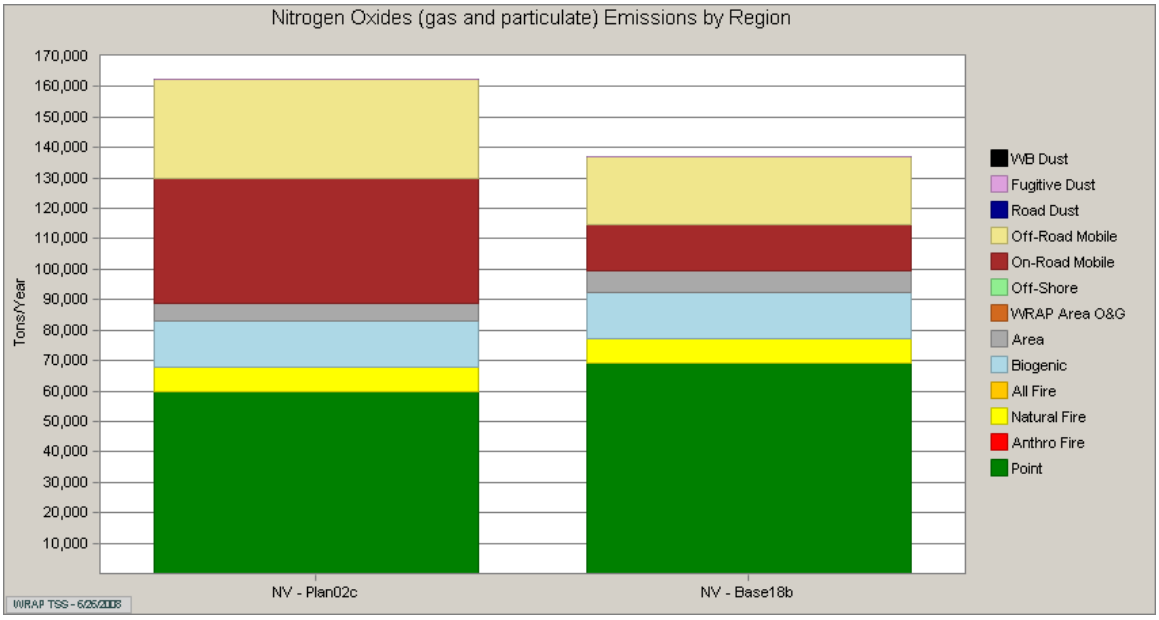
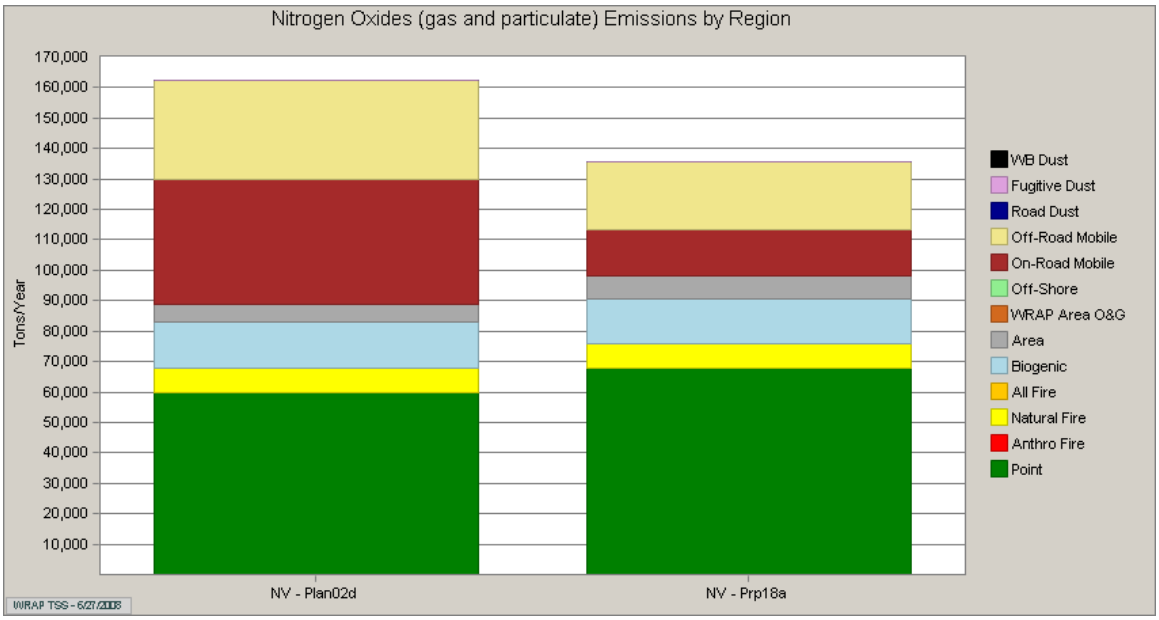


FIGURE 4-38

NEVADA NO_x PLAN02d AND PRP18a
EMISSION INVENTORY COMPARISON



The projected 2018 emissions inventories for both SO_2 and NO_x show substantial overall reductions from the 2002 baseline inventories. However, the PRP18a SO_2 projected inventory does not show as great reductions from 2002 for point sources as the Base18b and less total SO_2 reductions. For NO_x emissions, the total projected reductions are very similar, with a slight reduction in the PRP18a point source projection.

Comparison of the Plan02d and PRP18a emission inventories shows Nevada's total SO_2 emissions decreased by 33 percent from the baseline period to 2018, while SO_2 point source emissions decreased by 44 percent (see Table 3-7). Similarly, Nevada's total NO_x emissions decreased by 17 percent from the baseline to 2018, while NO_x point source emissions increased by 13 percent (see Table 3-8).

The projected overall particulate sulfate and nitrate concentration reductions at JARB1, shown on Table 4-6, are due to Nevada's and regional reductions of SO_2 and NO_x emissions. Organic aerosol PSAT results identify primary and secondary biogenic organic aerosol emissions as the dominant contributor to projected OC concentrations at JARB1 for 2018. These results also indicate primary organic aerosol emissions due to wildland fire are seasonally significant.

Regional WEP analyses appear to confirm the important contributions of projected sulfate and nitrate emissions from point sources in Idaho and Nevada, as well as the influence of nitrate emission from mobile sources in the states adjacent to Nevada to visibility impairment at JARB1 in 2018. These analyses also indicate the significant contributions of natural sources due to natural fire emissions of OC and EC and windblown dust emissions of PMF and PMC to visibility impairment at JARB1.

The results of the projected 2018 visibility and source apportionment modeling indicate the RPG for the Jarbidge WA will exceed the URP and identifies Nevada point sources of SO_2, as well as point and mobile sources of NO_x, as source area candidates for consideration of additional control measures during future regional haze planning periods.