Appendix 7-2: Integrated Planning Model Projections of Electric Generating Unit Emissions for the Regional Haze State Implementation Plan

Integrated Planning Model Projections of Electric Generating Unit Emissions for the Regional Haze State Implementation Plan

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ACRONYMS

Bext	Light Extinction
CAIR	Clean Air Interstate Rule
CENRAP	Central Regional Air Planning Association
CM	Coarse Mass
DRI	Desert Research Institute
EC	Elemental Carbon
EGU	Electric generating unit
EPA	United States Environmental Protection Agency
IEAS	Industrial Emissions Assessment Section
IPM	Integrated Planning Model
km	Kilometers
Mm^{-1}	Inverse Megameters
MW	Megawatt
NO_3^-	Nitrate
NO_X	Nitrogen oxides
Non-EGU	Non-Electric Generating Unit
POA	Primary Organic Aerosol
PSAT	Particulate Matter Source Apportionment Technology
Q/D	Emissions over distance to Class I area
SIP	State Implementation Plan
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate
TCEQ	Texas Commission on Environmental Quality
tpy	Tons per year
W20%	20 percent worst visibility days

Integrated Planning Model Projections of Electric Generating Unit Emissions for the Regional Haze State Implementation Plan

Executive Summary

The Regional Haze Rule implemented in 1999 by the United States Environmental Protection Agency (EPA) requires that states develop State Implementation Plans (SIPs) demonstrating that visibility in Federal Class I areas will be returned to natural conditions by the year 2064 (EPA, 1999). Each state is required to demonstrate visibility improvement in the state's own Class I areas and in other Class I areas potentially impacted by the state The future planning year for the initial SIPs is 2018.

Texas' assessment of visibility conditions is based largely on photochemical modeling that, in part, requires the input of emissions from electric generating units (EGUs). EGUs are important in the context of regional haze formation because of the potential for large emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X), which are converted by chemical reactions in the atmosphere to visibility-impairing sulfate and nitrate, respectively. Because of the relative amounts of SO_2 and NO_X emitted from EGUs, and meteorological conditions affecting sulfate and nitrate formation, sulfate formed from EGU-emitted SO_2 is a much more important contributor to visibility impairment in the Class I areas of interest to Texas than EGU-related nitrate formation.

Projecting EGU emissions for the long-planning horizon to 2018 is a highly complex task. Such projections are based on factors involving fuels, transportation, electric generating capacity, pollution control equipment, regulatory decisions, and other considerations. The effects of cap and trade programs such as the Clean Air Interstate Rule (CAIR) on emissions from specific EGUs are particularly difficult to project. Regional planning organizations used the Integrated Planning Model (IPM) to assist with projecting emissions from EGUs to future years. The IPM provides forecasts of least-cost generating capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints (EPA, 2007a).

The Central Regional Air Planning Association (CENRAP) used EGU emissions projected from the IPM as input to photochemical modeling of future visibility in Class I areas in support of the central states' regional haze SIPs and the tribes' Tribal Implementation Plans. CENRAP used a version of the IPM that was run with relatively low natural gas prices as a basis. An updated version of the IPM that is based on a shift toward more usage of coal and lignite is available, but due to scheduling constraints, CENRAP did not rerun its modeling based on the newer IPM version. The SIP planning schedule did not allow time to await new results, so the Texas Commission on Environmental Quality (TCEQ) conducted a technical analysis to determine whether it would be a viable option for the TCEQ to use CENRAP's existing modeling based on the initial IPM version.

The TCEQ's analysis compared various types of data from the initial and updated versions of the IPM. The TCEQ focused on SO_2 emissions since sulfate is the predominant contributor to EGU-related visibility impairment in the Class I areas of interest. One important finding was that statewide total SO_2 emissions projected to 2018 by both versions of the IPM were nearly the same. The TCEQ also conducted a somewhat in-depth analysis for 2018, whereby the TCEQ compared the potential for EGU impacts on Class I areas based on SO_2 emissions predicted by the two IPM versions. In this analysis, the TCEQ placed Texas EGUs into geographical groupings that are upwind of the Class I areas of interest on average, calculated average indices for the groupings based on EGU emissions and distances to the Class I areas, and compared results for both IPM versions. Based on this approach, the TCEQ found that for all of the Class I areas of interest, the potential visibility impacts from upwind geographical groupings of EGUs were the same or nearly the same for both IPM versions. The TCEQ points out that this method is non-rigorous in comparison with photochemical modeling and contains large uncertainties.

Based on evidence from the analyses the TCEQ conducted, the TCEQ concludes that photochemical modeling using inputs for EGUs from the initial version of the IPM may be a viable option for SIP planning in Texas. The conclusion is based on two primary findings: total Texas EGU emissions of SO_2 predicted by the initial and updated IPM versions are very similar for the planning year 2018; and potential impacts of EGUs on Class I areas, based on upwind groupings of EGU-emitted SO_2, are the same or nearly the same for both IPM versions.

Another option was to await CENRAP's photochemical modeling based on the updated IPM version. Implementing this option would provide technical information based on more current assumptions in IPM. However, CENRAP does not currently plan to revise the photochemical modeling based on the newer IPM version.. Furthermore, the TCEQ cannot be confident that the output from the updated IPM would actually be more representative of the future planning year than that from the initial version, since factors such as the cost effectiveness of various fuels may change.

Introduction

The Regional Haze Rule implemented in 1999 by the United States Environmental Protection Agency (EPA) requires that states develop State Implementation Plans (SIPs) demonstrating that visibility in Federal Class I areas will be returned to natural conditions by the year 2064 (EPA, 1999). The future planning year for the initial SIPs is 2018. Each state is required to demonstrate visibility improvement in the state's own Class I areas and in other Class I areas potentially impacted by the state. Texas' two Class I areas are Big Bend and Guadalupe Mountains National Parks. Other Class I areas of current interest in Texas' SIP development are in Oklahoma, Arkansas, Missouri, Louisiana, New Mexico, and Colorado.

Technical support for the initial visibility implementation plans is coordinated by the central states and tribes by the Central Regional Air Planning Association (CENRAP).

The assessment of visibility conditions is based largely on photochemical modeling that, in part, requires the input of emissions from electric generating units (EGUs). These sources are important in the context of regional haze formation because of the potential for large emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X), which are converted by chemical reactions in the atmosphere to visibility-impairing sulfate and nitrate, respectively. Because of the relative amounts of SO_2 and NO_X emitted from EGUs and meteorological conditions affecting sulfate and nitrate formation, sulfate formed from EGU-emitted SO_2 is a much more important contributor to visibility impairment in the Class I areas of interest to Texas than EGU-related nitrate formation.

Projecting EGU emissions for the long-planning horizon to 2018 is a highly complex task. Such projections are based on factors involving fuels, transportation, electric generating capacity, pollution control equipment, regulatory decisions, and other considerations. The effects of cap and trade programs such as the Clean Air Interstate Rule (CAIR) on emissions from specific EGUs are particularly difficult to project.

Regional planning organizations such as CENRAP used the Integrated Planning Model (IPM) to assist with the task of projecting emissions from EGUs to future years. The IPM, a proprietary model developed and run by ICF Consulting Inc., is a deterministic model that analyzes the projected impact of environmental policies on the electric power sector in the 48 contiguous states and District of Columbia. It provides forecasts of least-cost generating capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. The model can be used to evaluate the costs and emissions impacts of policies that limit or propose to limit emissions of various pollutants from the electric power sector, including those policies affecting emissions of SO_2 and NO_X (EPA, 2007a).

In developing the IPM emissions projections, the contractor used by the EPA and the Regional Planning Organizations accounted for EGU controls and emission reductions associated with the CAIR and other federal and state programs. For Texas, the IPM modeling accounted for such existing state programs as NO_X and SO_2 emissions caps and reductions in Texas under Senate Bill 7; NO_X emissions caps in the Houston-Galveston-Brazoria ozone nonattainment area; unit-specific NO_X emissions limits or system-wide averaging emissions caps in the Dallas-Fort Worth ozone nonattainment area; and unit-specific NO_X emissions limits or system-wide averaging emissions caps in east and central Texas.

The IPM was run with an EPA-developed procedure to project new EGUs to 2018 (EPA, 2007b). Based on economic and logistic considerations, the procedure places a high priority on locating new units at existing plants. In consideration of current air quality, the procedure also projects locations of new units based on a hierarchy of county attainment status, such that the units are located in pollutant attainment counties, particulate matter nonattainment counties, and eight-hour ozone nonattainment counties, in that order.

The TCEQ included newly permitted EGUs in the 2018 IPM projections and conservatively, no IPM-projected new units were removed from the simulation with the addition of the permitted facilities.

Extensive documentation of the IPM, including assumptions on emissions controls, is provided at the following URL: <http://www.epa.gov/airmarkets/progsregs/epa-IPM/index.html>.

In 2005, the EPA released the results and documentation for the IPM Version 2.19 (EPA, 2007a). Inputs to the IPM Version 2.19 were constructed when natural gas prices were relatively low. Thus, this IPM version projected a preponderance of new natural gas-fired units in 2018, as opposed to new solid fuel-fired units, to meet electric generating capacity needs. To date, CENRAP has used projected emissions and related information from IPM Version 2.19 in its photochemical modeling.

In early 2007, the EPA released results and documentation for the IPM Version 3.0 (EPA, 2007a). The newer version accounted for a shift in projected fuel usage from natural gas to more use of other fuels (such as coal or lignite) that were more economical to use than natural gas. As expected, the IPM Version 3.0 projected few new natural gas-fired units for the 2018 SIP planning year, as opposed to the IPM Version 2.19 projections. The newer version primarily projected coal- or lignite-fired units for new capacity.

Results from the IPM Version 3.0 are available, but due to time constraints CENRAP did not rerun its photochemical modeling with the new IPM version as a basis. Based on the TCEQ's regional haze SIP schedule, there is insufficient time to await the results of revised modeling based on the new IPM version. Thus, the Air Quality Division staff conducted a technical analysis to determine the adequacy of using modeling results based on the earlier IPM Version 2.19. In conducting this analysis, the TCEQ assessed differences in projections from the two IPM versions from the standpoint of electric generating capacity, EGU emission levels, geographic distribution of emissions, and meteorological influences. The TCEQ was particularly interested in whether projections of EGU emissions from one version of the IPM might be more conservative than those from the other version.

Description of Analysis Tasks

For coal/lignite and gas as fuels, the TCEQ compared electric generating capacity projected for Texas in 2018 by both versions of the IPM. The TCEQ also compared total EGU emissions projected for Texas by both versions.

For the two IPM versions, the TCEQ conducted analyses based on unit-specific emissions projections for 2018. As part of this comparison, the TCEQ used a procedure to account not only for emissions but also geographic location of emissions relative to Class I areas. In this portion of the analysis, the TCEQ accounted for meteorological influences on the emissions impacts on the Class I areas of interest.

To account for geographic location of emissions relative to Class I areas, and thus the relative importance of emissions impacts on such areas, the TCEQ calculated "Q/D" for EGUs included in the two IPM versions. The index Q/D is the ratio of emissions from an EGU to the distance from the unit to a Class I area. For example, if a unit emits 1,000 tons/year of SO_2 and is 100 kilometers from a Class I area, its impact on the Class I area would be greater than if it were 300 kilometers from the receptor, all other factors being the same. In calculating Q/D for EGUs, the TCEQ considered only those EGUs projected in either IPM version to emit SO_2. That is, the TCEQ considered only units projected by the IPM to be fired with coal, lignite, or other fuel that emits SO_2 in relatively significant amounts when combusted. As noted earlier, available information has indicated that visibility impairment in Class I areas of interest to Texas is predominantly sulfate related. CENRAP's contractor, Environ Corporation, used its Particulate Matter Source Apportionment Technology (PSAT) (Environ, 2007) to develop the information

the TCEQ used in making the conclusion that it would be sufficient to focus on SO_2 emissions in the analysis.

In the Q/D approach, the TCEQ defined geographical groupings of EGUs within Texas, calculated the year 2018 average Q/Ds for the groupings for both IPM versions, and then compared the results. To account for meteorological factors affecting the impacts of Texas EGUs on each Class I area on poor visibility days, the groupings were defined using "trajectory residence time plots." These plots show the percentage of a historical collection of back trajectories from a Class I area on poor visibility days that "resided in" or passed through each of the many grid cells overlaid on the state. For example, if residence time plots for a Class I area showed that eastern Texas was upwind of the area on poor visibility days in the historical period, then EGUs in eastern Texas would be included in the source grouping for which an average Q/D would be calculated for each IPM version.

The residence time plots used in this analysis were constructed by Desert Research Institute (DRI), and made available by DRI on its web site (DRI, 2007). For most Class I areas, the back trajectories upon which the residence time plots were based covered the three-year period 2000-2002.

Based on the ranges of residence time percentages shown in DRI's plots, the TCEQ determined that consideration of geographical source groupings with trajectory residence times of 14 percent or greater would generally be reasonable. One consideration in setting the threshold at 14 percent was that the legends for the residence plots indicate that 14 percent is actually the lower end of a range between 14 and 28 percent. Because of the large range of directions from which the residence time plots show wind flow on poor visibility days, it would not generally be feasible to select a residence time threshold below the 14 to 28 percent range. However, there are some plots for which TCEQ had to use lower thresholds in order to determine source groupings

In summary, the TCEQ conducted the following tasks to determine whether IPM Version 2.19 would be adequate for use in the regional haze SIP modeling, in lieu of awaiting the results of IPM Version 3.0:

- compared electric generating capacity in Texas as projected by each IPM version for the year 2018;
- compared total EGU emissions in Texas projected by each IPM version for the year 2018;
- compared unit-specific emissions in Texas projected by each IPM version for the year 2018;
- for each Class I area and for each IPM version, calculated Q/D for those Texas EGUs projected in either IPM version to emit SO_2 in 2018;
- to account for meteorological influences, defined geographical groupings of Texas EGUs upwind of the Class I areas of interest, based on residence time plots for back trajectories originating at the Class I areas on poor visibility days;
- for the EGU groupings defined for the Class I areas, calculated an average Q/D for the two IPM versions; and
- compared the average Q/Ds for the two IPM versions for the various EGU groupings.

Class I Areas of Interest for the Analysis

As noted earlier, a state is required by the 1999 Regional Haze Rule to assess visibility impacts on Federal Class I areas located not only within the state, but also outside the state. In conducting the analysis comparing the two IPM versions, the TCEQ focused on the impacts of Texas EGUs on the following Federal Class I areas:

- Big Bend National Park (BIBE), Texas

- Guadalupe Mountains National Park (GUMO), Texas
- Carlsbad Caverns National Park, New Mexico
- Wichita Mountains Wildlife Refuge (WIMO), Oklahoma
- Caney Creek Wilderness Area (CACR), Arkansas
- Upper Buffalo Wilderness Area (UPBU), Arkansas
- Hercules Glades Wilderness Area (HEGL), Missouri
- Breton Island National Wilderness Area (BRET), Louisiana
- Salt Creek Wilderness Area (SACR), New Mexico
- White Mountain Wilderness Area (WHIT), New Mexico
- Great Sand Dunes National Monument (GRSA), Colorado

The locations of the preceding Class I areas are depicted in Figure 1, which shows all regional Class I areas.

Big Bend and Guadalupe Mountains National Parks were selected for this analysis because they are located within Texas. The other Class I areas were selected because of the relative potential for EGU impacts from Texas, or current interest from other states in Texas' impacts. The TCEQ used the PSAT tool output to determine the relative potential for impacts of Texas EGUs on Class I areas.

Comparison of Electric Generating Capacity for the Two IPM Versions

Table 1 shows Texas generating capacity, by fuel type, as projected by IPM Versions 2.19 and 3.0 to the year 2018. Generating capacity in 2005 is shown for comparison (EPA,2007c). The IPM Version 2.19, used by CENRAP, projected an approximately 28 percent increase in combined total generating capacity in Texas for coal/lignite and natural gas from 2005 to 2018. The TCEQ believes this projected total increase is reasonable based in part on population projections from the Office of the Texas Comptroller, which show about a 20 percent increase in population from 2005 to 2018 (Office of the Texas Comptroller, 2008). Also, generating capacity projections from the Electric Reliability Council of Texas (ERCOT) show continued growth of coal/lignite- and gas-fired capacity for the ERCOT region at least through 2013, the furthest projection year available (ERCOT, 2007). The IPM Version 2.19 projected an approximately 14 percent increase in coal/lignite-fired generating capacity in Texas from 2005 to 2018, and about a 32 percent increase in gas-fired capacity. ERCOT projections to 2013 show greater growth in coal/lignite-fired than natural gas-fired capacity based on utility planning that is publicly available. Both the IPM Version 2.19 and ERCOT projections show a greater amount of gas-fired capacity in the latest available projection year than coal/lignite-fired capacity.

The TCEQ acknowledges that the future growth of generating capacity for these fuel types will be related to more than population growth (e.g., fuel prices, fuel availability, environmental policies, growth in renewable energy resources, and other related factors), and that both the population projections and ERCOT generating capacity projections are subject to uncertainties as are the IPM projections.

Since IPM Version 3.0 was run after coal and lignite became less expensive to use than natural gas, the TCEQ expected the results showing that IPM Version 3.0 projected greater growth in coal/lignite-fired than gas-fired generating capacity than did IPM Version 2.19. The total generating capacity projected for Texas by IPM Version 3.0 is lower than that for IPM Version 2.19, for reasons that are not readily apparent since the projections of generating capacity are tied to so many factors. Also, the total generating capacity projected for 2018 by IPM 3.0 is less than the total for 2005, for reasons that are not apparent to the TCEQ.

Comparison of Texas EGU Emissions for the Two IPM Versions

Table 2 shows total Texas EGU emissions, by fuel type, projected by the IPM Versions 2.19 and 3.0 for the year 2018. Emissions for the modeling baseline year of 2002 are shown for

comparison. As a result of the implementation of federal and state programs, total emissions projected for Texas for 2018 by both IPM versions are much lower than those shown for 2002. Total sulfur dioxide emissions projected to 2018 by the IPM Version 3.0 were approximately the same as those projected by Version 2.19, even though the IPM Version 3.0 projected about a 14 percent greater coal-fired capacity in 2018 than did Version 2.19. An explanation for these trends is not readily apparent since the projections of emissions made by the IPM are tied to so many factors. However, even with the IPM Version 3.0's greater projected coal-fired capacity, emissions of sulfur dioxide predicted by this version would not necessarily be greater than those predicted by Version 2.19. The projected emissions are a function not only of capacities for the fuel types but also of the assumptions upon which each IPM version are based, including the extent to which sources implement emission controls or purchase credits in response to the CAIR cap and trade program.

The IPM Version 3.0 projected about a ten percent decrease in nitrogen oxides from Version 2.19. The TCEQ believes that the projected decrease is primarily due to the fact that Version 3.0 retired a large number of nitrogen oxide-emitting gas-fired generating units.

The fact that total predicted emissions of SO_2 are nearly the same for the two IPM versions provided initial evidence that the use of IPM Version 2.19 may be adequate for regional haze photochemical modeling. Further analyses, discussed later, were necessary since the results of this initial task apply only on a very broad geographical scale.

Comparison of Unit-Specific Emissions

After comparing total emissions for Texas, the TCEQ compared unit-specific emissions projected by the two IPM versions for the year 2018 (see Tables 3 and 4, and Figures 2 and 3). Modeling emissions for the 2002 baseline year and average actual emissions for 2000-2005 are shown for comparison. Unit-specific comparisons show that in some cases, IPM Version 2.19 projected larger emissions than Version 3.0, while for other units, the opposite was observed.

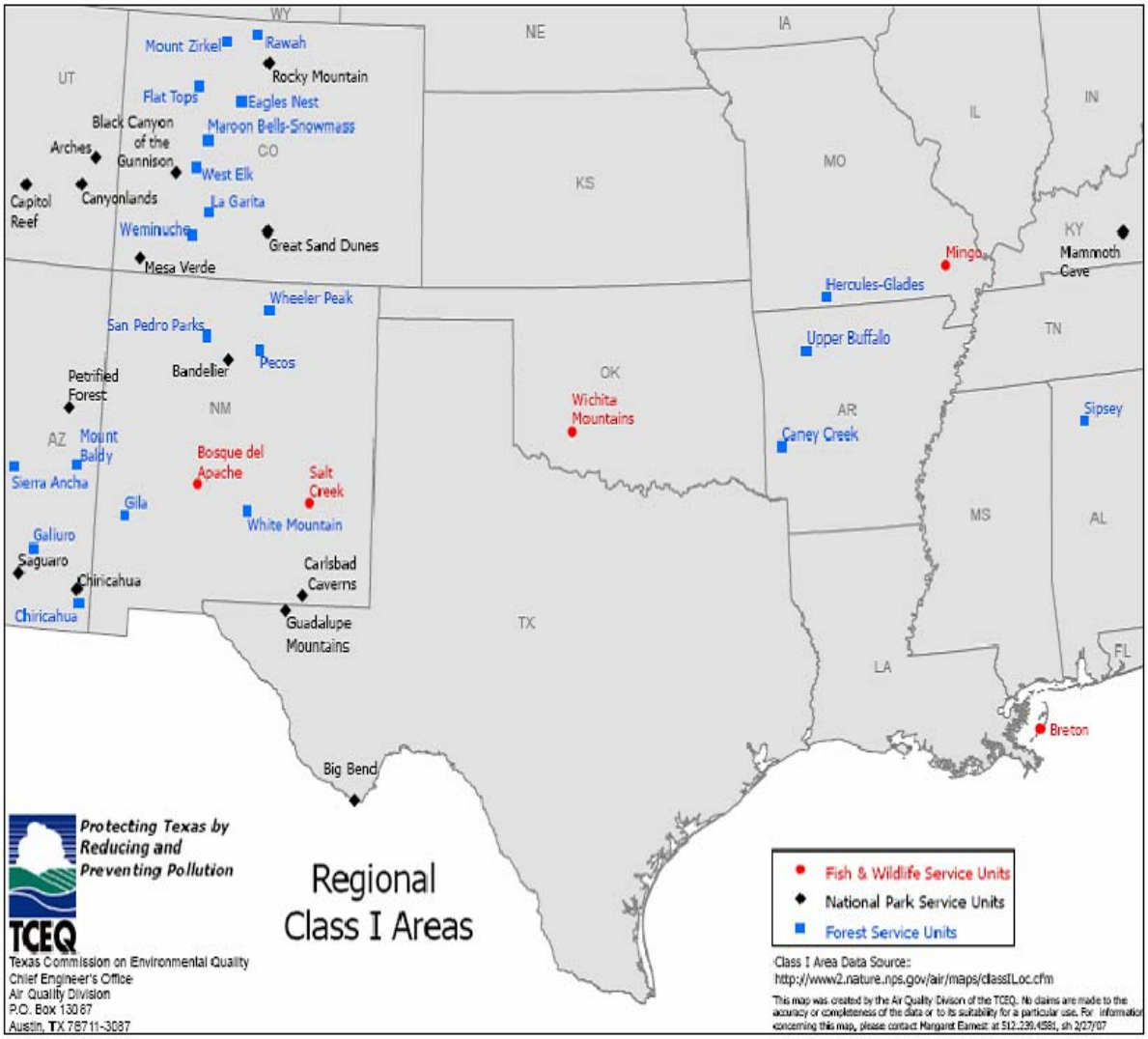


Figure 1. Federal Class I Areas in Texas and Surrounding States

Table 1. Electric Generating Capacity In Texas - IPM 2.19 Versus IPM 3.0

Fuel	2005 Generating Capacity (MW)	2018 Generating Capacity IPM 2.19 (MW)	2018 Generating Capacity IPM 3.0 (MW)	Percent Difference in IPM Versions
Coal or Lignite	19,836	22,611	25,779	14
Gas	67,604	89,023	58,475	-34
Other	291	195	231	18
Total	87,731	111,829	84,485	-24

Source of 2018 data: CENRAP, 2007
Source of 2005 data: EPA, 2007c

Note: "Other" includes such fuels as fossil waste, but does not include hydroelectric, nuclear, solar, or wind energy.

Table 2. Texas Emissions of SO_2 and NO_X from EGUs - IPM 2.19 Versus IPM 3.0

Fuel	SO_2 Emissions 2002 - CENRAP Modeling Baseline (tpy)	SO_2 Emissions 2018 - IPM 2.19 (tpy)	SO_2 Emissions 2018 - IPM 3.0 (tpy)	% Difference in IPM Versions	NO_X Emissions 2002 - CENRAP Modeling Baseline (tpy)	NO_X Emissions 2018 - IPM 2.19 (tpy)	NO_X Emissions 2018 - IPM 3.0 (tpy)	% Difference in IPM Versions
Coal or Lignite	531,379	350,224	344,636	-2	165,156	122,663	125,358	2
Gas	738	0	0	-	77,376	35,543	17,589	-51
Other	4,568	0	4,890	-	3,611	1,614	810	-50
Total	536,685	350,224	349,526	0	246,143	159,820	143,757	-10

Source of data: CENRAP, 2007

Table 3. Comparison of SO_2 Emissions from IPM 2.19 and IPM 3.0 - Texas EGUs

Plant	County	SO_2 Emissions-2002 Modeling Baseline (tpy)	SO_2 Emissions-Average of Actuals 2000-2005 (tpy)	SO_2 Emissions 2018 IPM 2.19 (tpy)	SO_2 Emissions 2018 IPM 3.0 (tpy)	Difference in IPM Emissions of SO_2 (tpy)
Northeast Texas						
Big Brown	Freestone	77,860	82,272	46,794	26,866	-19,928
Monticello	Titus	86,233	83,287	51,707	32,067	-19,640
Martin Lake	Harrison	66,394	66,593	35,739	36,920	1,181
Welsh	Titus	35,838	35,287	14,174	35,528	21,354
Pirkey	Harrison	19,476	17,428	19,483	13,098	-6,385
Southeast Texas						
W.A. Parish	Fort Bend	60,234	56,702	15,355	44,762	29,407
AES Deepwater	Harris	4,370	2,131	0	4,678	4,678
Mid Coastal Texas						
Coleto Creek	Goliad	14,289	14,314	16,100	13,502	-2,598
BP Chemicals Green Lake	Calhoun	3	ND	0	172	172
Formosa Plastics	Calhoun	2	ND	0	2,496	2,496
Valley						
La Palma	Cameron	2	40	0	1541	1541
Central Texas						
Sandow	Milam	23,305	24,635	13,595	14,445	850
Oak Grove	Robertson	0	ND (facility not permitted)	0	15,086	15,086
Sandy Creek	McLennan	0	0	3,585	3,585	0
Twin Oaks	Robertson	5088	5180	1,674	982	-692
NRG Limestone	Limestone	29,267	26,150	17,702	10,642	-7,060
Gibbons Creek	Grimes	10,816	11,334	2,653	2,050	-603
City of Bryan	Brazos	0	1	0	107	107
Dansby Power Plant	Brazos	1	3	0	107	107
Fayette Power Plant	Fayette	31,105	31,105	23,327	4,964	-18,363
South Central Texas						
Deely/Sommers/ Spruce	Bexar	33,300	24,857	27,953	24,888	-3,065
San Miguel	Atascosa	13,167	11,670	6,552	7,712	1,160
West Central Texas						
San Angelo Power Station	Tom Green	2	4	973	0	-973
North Central Texas						
Oklaunion	Wilbarger	3,751	4,192	7,102	6,594	-508
Panhandle						
Celanese Chemical Manufacturing	Gray	2,024	ND	1,161	660	-501
Tolk Station	Lamb	24,874	24,693	21,962	22,946	984
Harrington Station	Potter	26,968	25,719	22,715	23,087	372
Borger Plant and Engineered Carbons Cogen	Hutchinson	0	ND	0	120	120

Note: ND - No data found in Acid Rain Database

Table 4. Comparison of NO_X Emissions from IPM 2.19 and IPM 3.0 - Texas EGUs*

Plant	County	NO_X Emissions 2002 Modeling Baseline (tpy)	NO_X Emissions-Average of Actuals 2000-2005 (tpy)	NO_X Emissions 2018 IPM 2.19 (tpy)	NO_X Emissions 2018 IPM 3.0 (tpy)	Difference in IPM Emissions of NO_X (tpy)
Northeast Texas						
Big Brown	Freestone	7,203	9,958	7,436	6,591	-845
Monticello	Titus	15,919	15,964	14,249	12,683	-1,566
Martin Lake	Harrison	18,464	19,114	18,957	15,697	-3,260
Welsh	Titus	13,316	15,347	6,204	10,938	4,734
Pirkey	Harrison	4,953	6,179	4,999	4,512	-487
Southeast Texas						
W.A. Parish	Fort Bend	14,956	12,272	3,863	4,461	598
AES Deepwater	Harris	3,643	3,587	1,578	386	-1,192
Mid Coastal Texas						
Coleto Creek	Goliad	3,563	4,311	4,397	3,562	-835
BP Chemicals Green Lake	Calhoun	0	ND	0	205	205
Formosa Plastics	Calhoun	1,565	ND	160	979	819
Valley						
La Palma	Cameron	754	854	217	1,015	798
Central Texas						
Sandow	Milam	7,670	6,345	8101	5,918	-2,183
Oak Grove	Robertson	0	ND (facility not permitted)	0	6,286	6,286
Sandy Creek	McLennan	0	0	1,793	1,793	0
Twin Oaks	Robertson	2,400	2,356	2,404	2,027	-377
NRG Limestone	Limestone	13,461	14,126	10,958	10,130	-828
Gibbons Creek	Grimes	2,218	2,822	2,006	2,093	87
City of Bryan	Brazos	10	65	159	151	-8
Dansby Power Plant	Brazos	197	208	189	148	-41
Fayette Power Plant	Fayette	19,118	15,493	7,865	7,143	-722
South Central Texas						
Deely/Sommers/ Spruce	Bexar	674	11,147	8,762	8170	-592
San Miguel	Atascosa	6,702	5,478	4,315	3611	-704
West Central Texas						
San Angelo Power Station	Tom Green	221	379	891	22	-869
North Central Texas						
Oklaunion	Wilbarger	8,711	7,780	6,294	6,177	-117
Panhandle						
Celanese Chemical Manufacturing	Gray	1,249	ND	523	649	126
Tolk Station	Lamb	12,115	12,264	5,345	5,577	232
Harrington Station	Potter	13,139	13,511	5,697	5,626	-71
Borger Plant and Engineered Carbons Cogen	Hutchinson	0	ND	0	241	241

Note: Because visibility impairment in Class I areas affected by Texas is primarily sulfate-related, NO_X emissions are shown only for those EGUs predicted by either IPM 2.19 or IPM 3.0 to have SO_2 emissions in 2018.

ND - No data found in Acid Rain Database

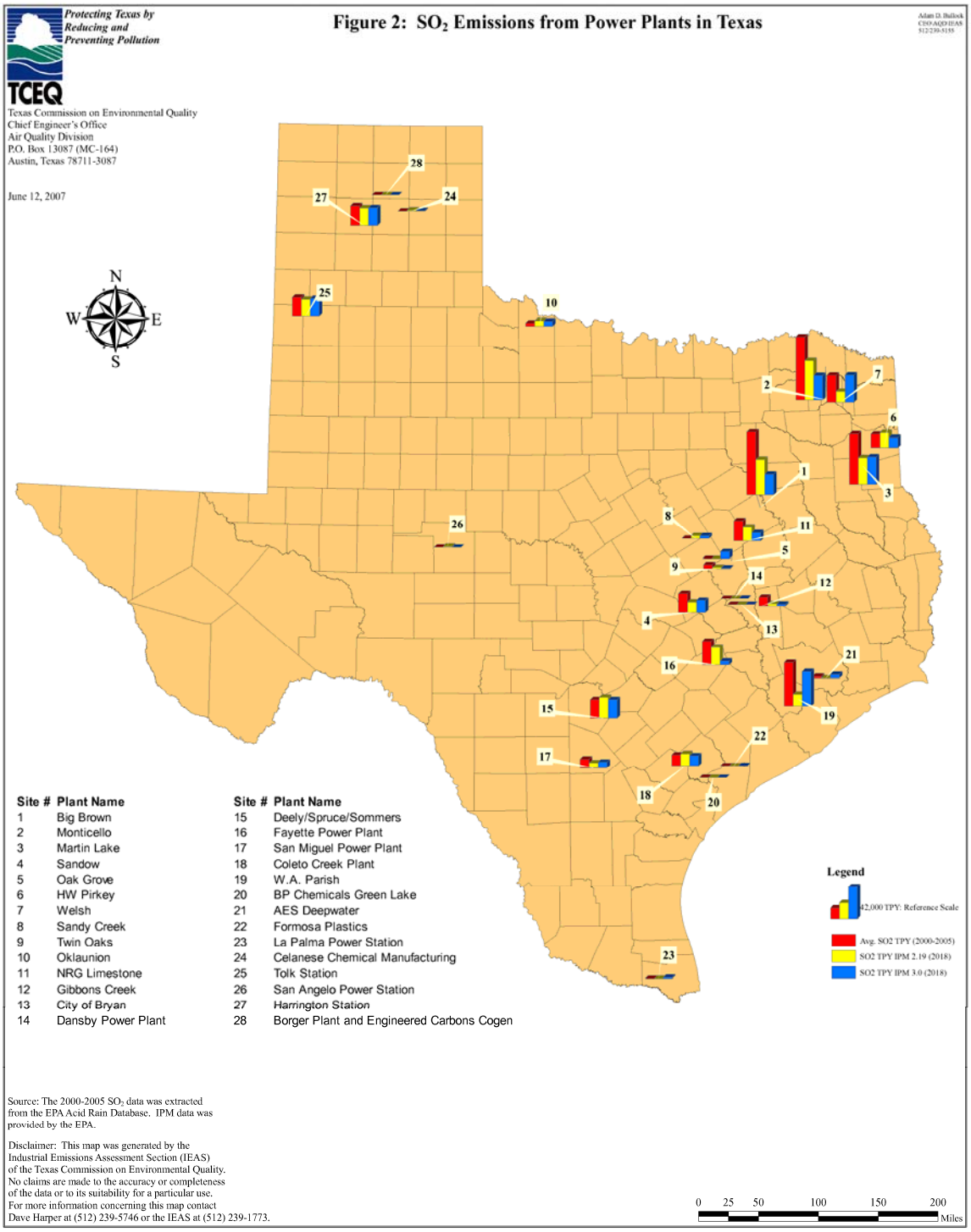


Figure 2. SO_2 Emissions from Power Plants in Texas

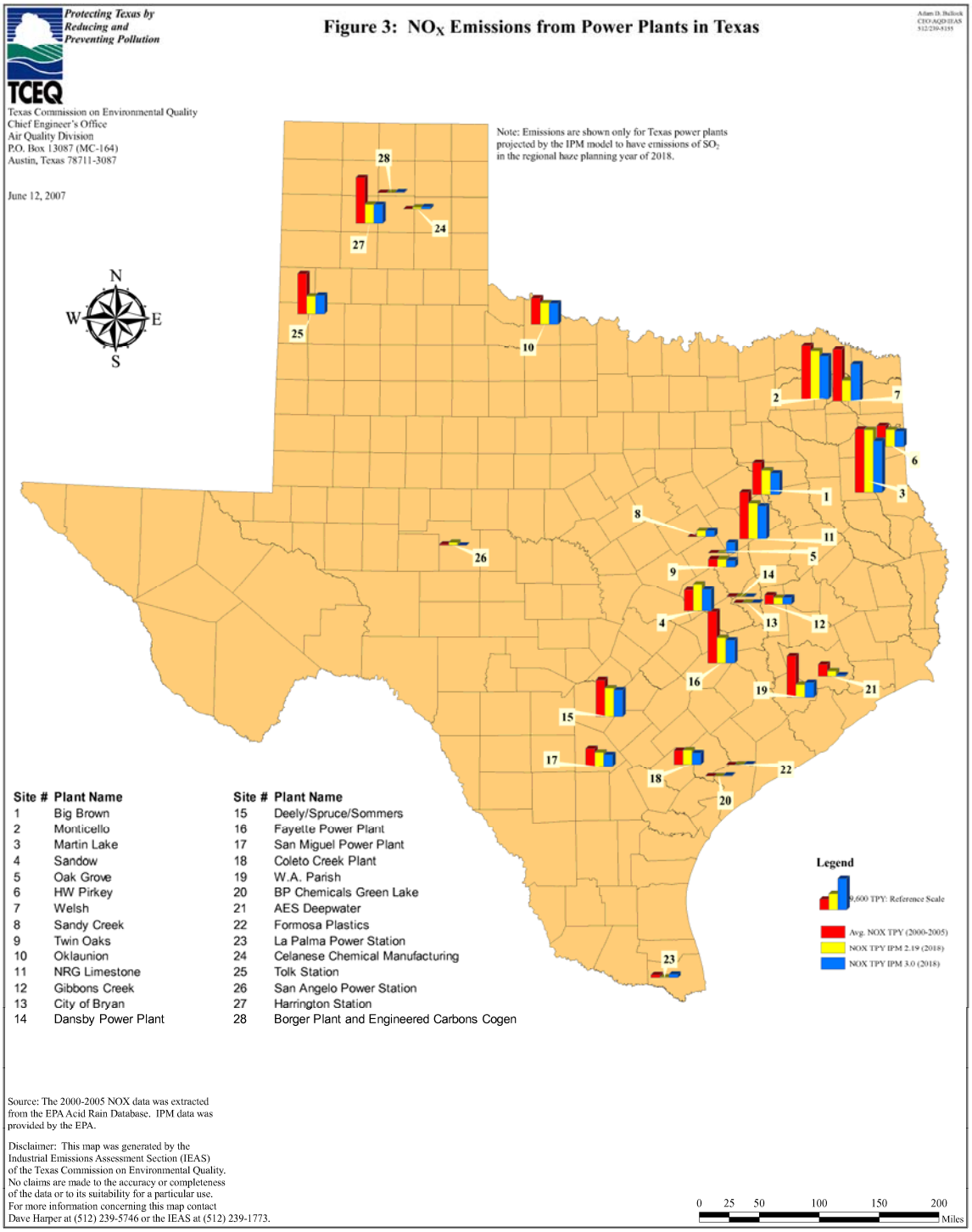


Figure 3. NO_X Emissions from Power Plants in Texas

Reasons for the differences in projected emissions for specific units for the two IPM versions are not readily apparent since the projections are tied to so many factors in the IPM (e.g., the complexities of cap and trade programs).

Detailed Analyses for Various Class I Areas

Big Bend National Park, Texas

In comparing the results of the two IPM versions for Big Bend National Park (Big Bend) in Texas, the TCEQ first looked at the projected contribution of various pollutant components to visibility impairment in 2018 based on the 20 percent worst-case visibility days in the baseline period 2000-2004 to determine whether the TCEQ could focus solely on SO_2 or NO_X emissions from EGUs, or whether the TCEQ needed to consider both pollutants. To make this determination, the TCEQ reviewed the output from PSAT developed by Environ Corporation (Environ, 2007). The PSAT results for the Class I areas of interest are based on photochemical modeling Environ has conducted to date for CENRAP in support of the regional haze SIPs. For Texas, PSAT results were available for three emission source regions in the state: East Texas, Texas Gulf Coast, and West Texas (see Figure 4). Although the available PSAT results do not incorporate EGU emissions based on IPM Version 3.0, the TCEQ believes the results are adequate for demonstrating the relative contributions of various source categories and pollutants to visibility impairment in the Class I areas.

Figures 5, 6, and 7 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in Big Bend for the 20 percent worst visibility days in the baseline period of 2000-2004. Results shown in Figures 5, 6, and 7 are based on emissions in the East Texas, Texas Gulf Coast, and West Texas source regions, respectively. The bar graphs in the figures show that for EGUs in Texas, sulfate is projected by PSAT to be the predominant pollutant component causing visibility impairment in Big Bend. PSAT results also show that when states surrounding Texas are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Big Bend. Thus, the TCEQ concentrated on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for Big Bend.

As explained previously, Q/D calculations provide a means of representing the relative impact of emission sources on receptors such as Big Bend. For both IPM Versions 2.19 and 3.0, the TCEQ calculated Q/D for Big Bend for all EGUs represented in the models so that the TCEQ could compare the results of the two IPM versions. However, before comparing Q/D data sets for Big Bend, the TCEQ grouped the EGUs and associated Q/Ds geographically based on the potential for the EGUs in the group to be upwind of Big Bend on the 20 percent worst visibility days. To assist with the grouping of EGUs upwind of Big Bend, the TCEQ used a DRI residence time plot based on back trajectories from Big Bend for the period 2000-2002. As previously noted, these residence time plots show the percentage of the historical collection of back trajectories on poor visibility days that passed through each of the grid cells overlaid on the state.

Figure 8 shows the residence time plot for Big Bend. This plot indicates that the SO_2-emitting EGUs located in the Rio Grande Valley, parts of Central Texas, and parts of Coastal Texas could be grouped for the purposes of calculating an average Q/D for the two IPM versions.

Results presented in Table 5 show that for the two IPM versions, the average Q/Ds for the Big Bend source grouping are similar. The data show that there can be large differences in Q/D on a plant-specific basis; however, the TCEQ can base its conclusions on the Q/D averages for the geographical grouping derived from the residence time plot, since the plot is applicable to a long span of time, as are visibility impairment projections based on photochemical modeling.

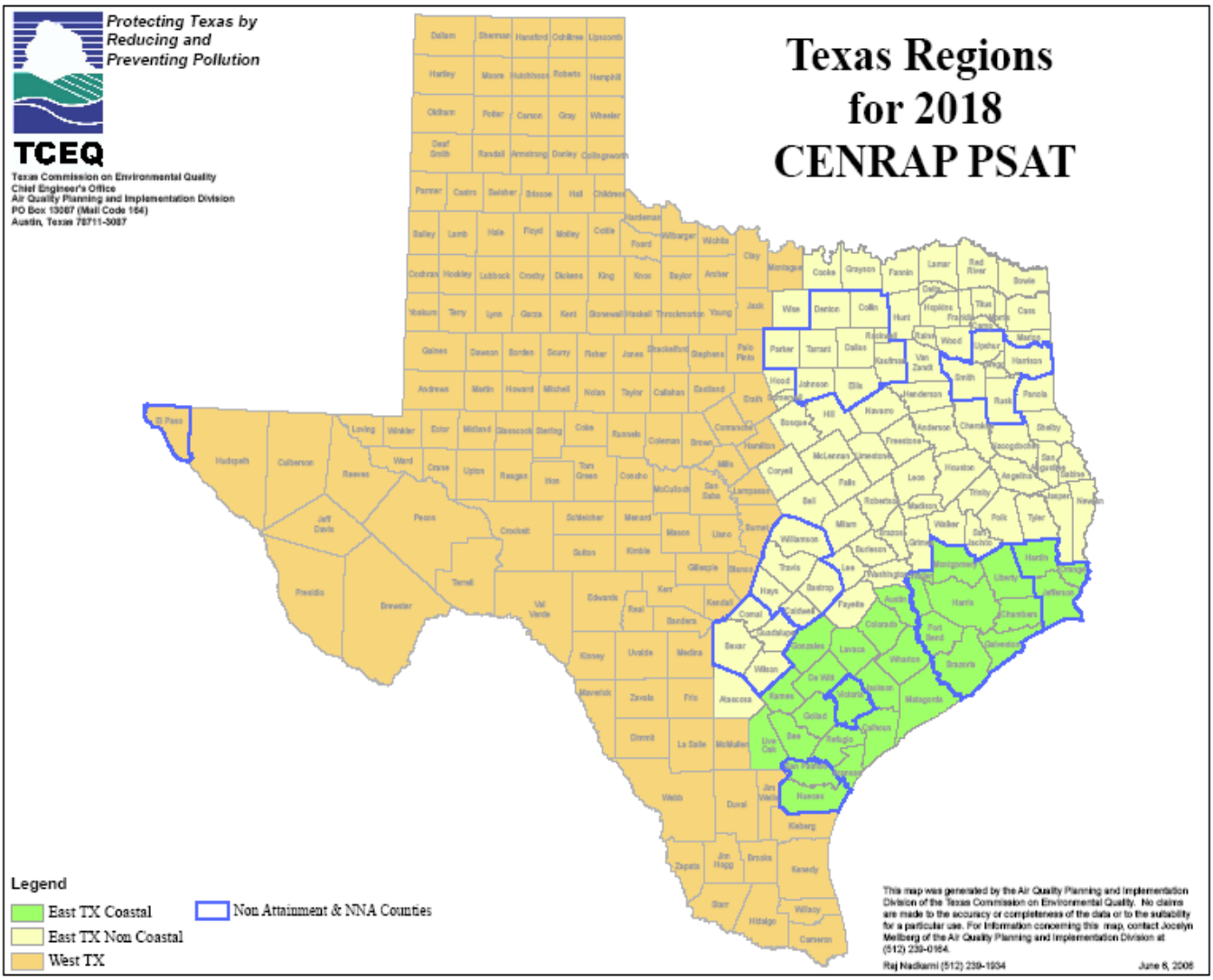
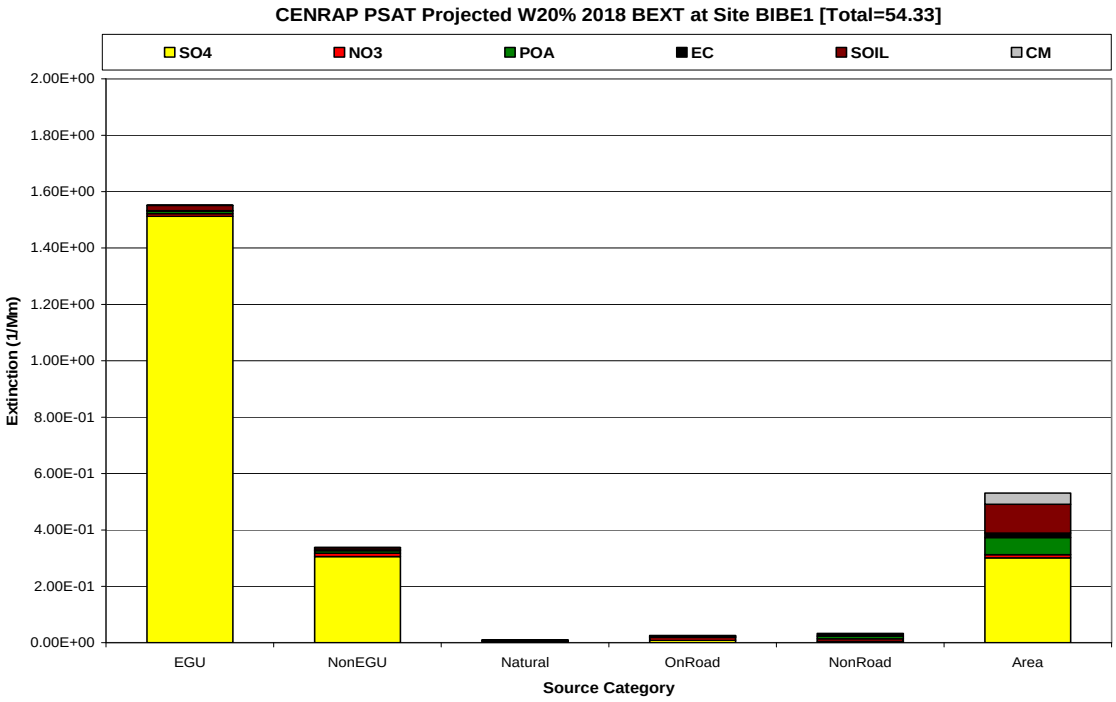
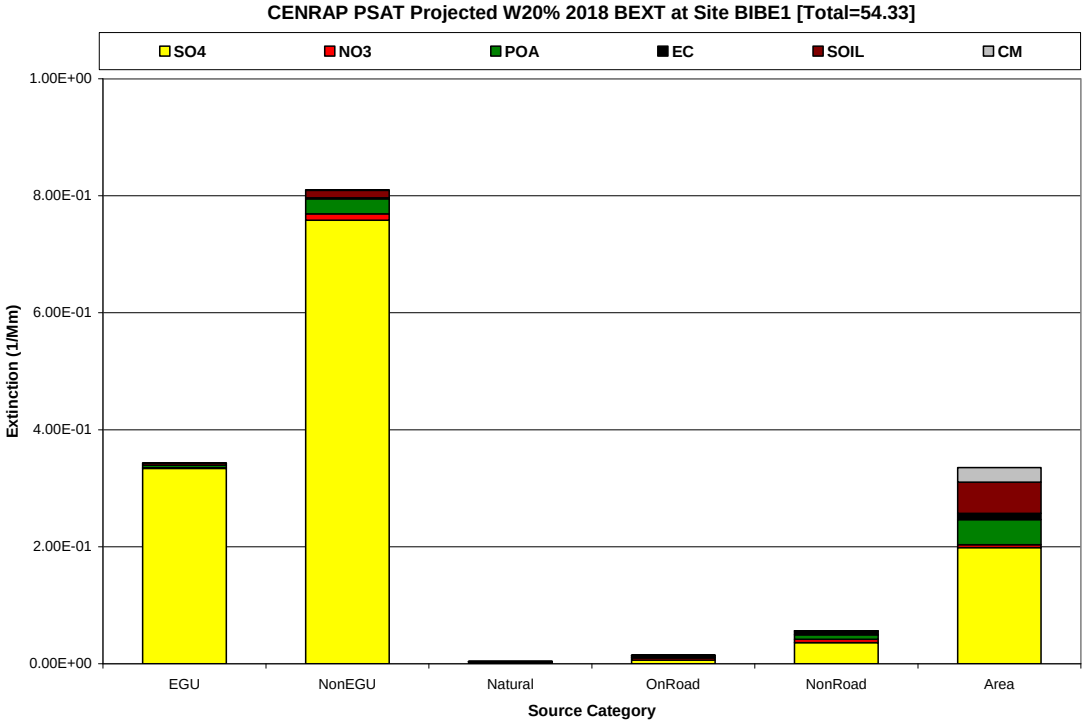


Figure 4. Texas Emissions Regions for PSAT Analysis



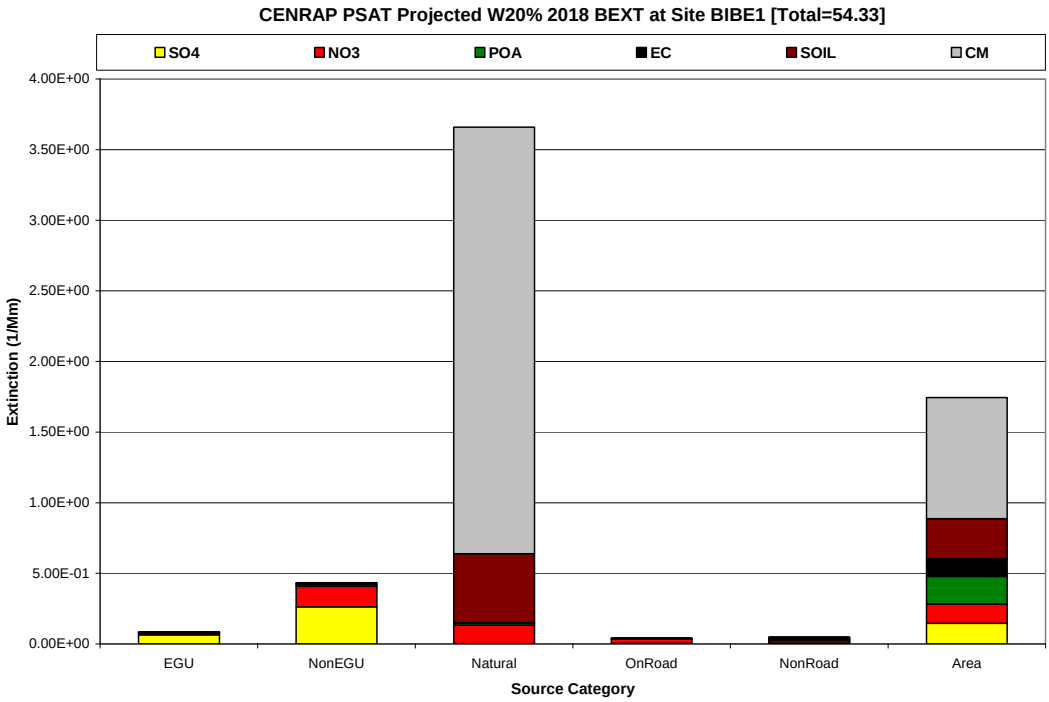
Source: Environ, 2007

Figure 5. Projected Contributions to Light Extinction at Big Bend from East Texas Region – 20 Percent Worst Visibility Days – 2018



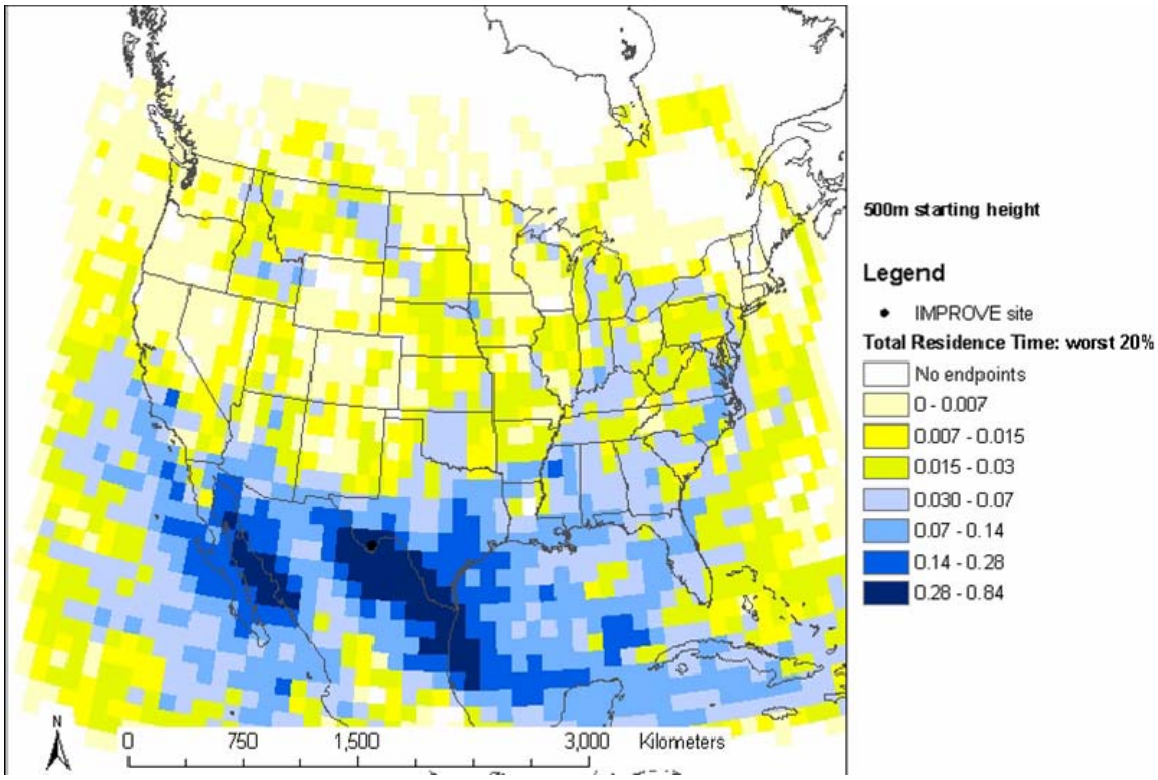
Source: Environ, 2007

Figure 6. Projected Contributions to Light Extinction at Big Bend from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 7. Projected Contributions to Light Extinction at Big Bend from West Texas Region – 20 Percent Worst Visibility Days – 2018



Source: DRI, 2007

Figure 8. Residence Time Plot for Big Bend for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 5. Q/D Analysis for Big Bend Based on Residence Time Plot

Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone			
Monticello	Titus			
Martin Lake	Harrison			
Welsh	Titus			
Pirkey	Harrison			
Southeast Texas				
W.A. Parish	Fort Bend	21	60	
AES Deepwater	Harris			
Mid Coastal Texas				
Coleto Creek	Goliad	26	22	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	4	
Valley				
La Palma	Cameron	0	2	
Central Texas				
Sandow	Milam	22	23	
Oak Grove	Robertson	0	23	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	6	6	
Twin Oaks	Robertson	3	2	
NRG Limestone	Limestone	25	15	
Gibbons Creek	Grimes	4	3	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	36	8	
South Central Texas				
Deely/Sommers/Spruce	Bexar	57	51	
San Miguel	Atascosa	14	16	
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb			
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**13**	**15**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.

Guadalupe Mountains National Park, Texas
Figures 9, 10, and 11 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in Guadalupe Mountains National Park (Guadalupe Mountains) for the 20 percent worst visibility days in the baseline period of 2000-2004, and for the three source regions in Texas. The bar graphs in the figures show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when states surrounding Texas are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Guadalupe Mountains. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

Figure 12 shows the residence time plot for Guadalupe Mountains. This plot, based on back trajectories from Guadalupe Mountains, indicates that the SO_2-emitting EGUs located in much of Texas (excluding southeast Texas and much of the Panhandle) can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 6 show that for this Class I area, the average Q/D for IPM Version 2.19 is slightly greater than that for Version 3.0.

Carlsbad Caverns National Park, New Mexico
PSAT results were not available for Carlsbad Caverns National Park (Carlsbad Caverns), but Figures 9, 10, and 11 for Guadalupe Mountains are representative because of the very close proximity of the two Class I areas. These PSAT graphics and others for surrounding states indicate that TCEQ should focus on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for Carlsbad Caverns.

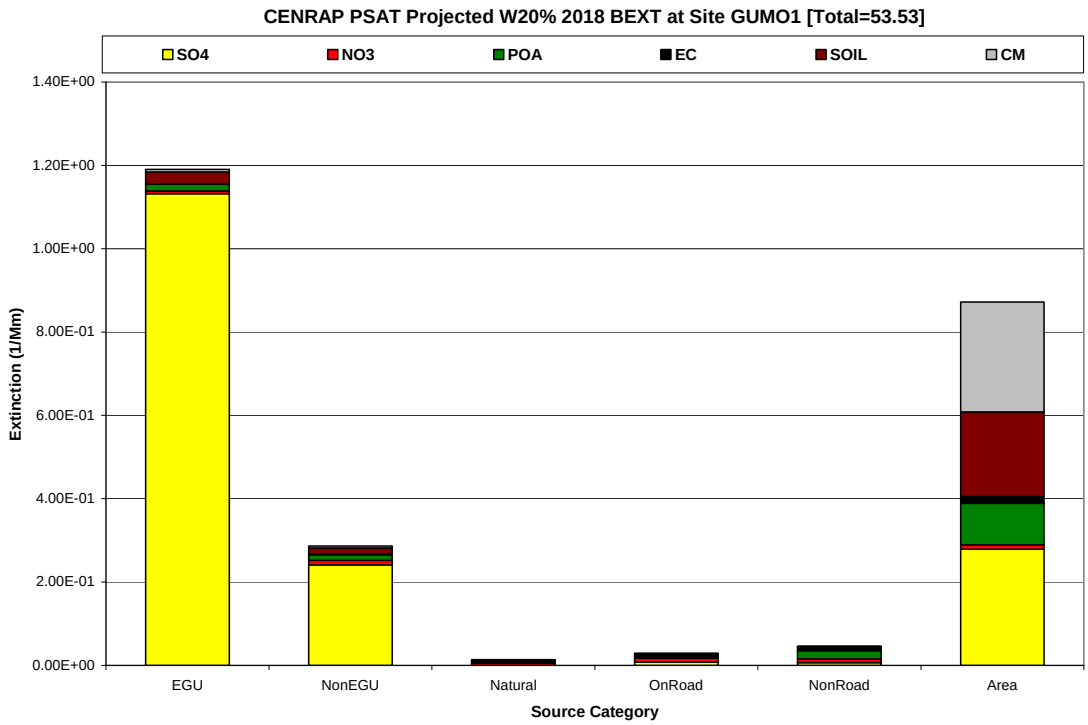
Figure 13 shows the residence time plot for Carlsbad Caverns. This plot indicates that all SO_2-emitting EGUs in Texas can be grouped together for comparing Q/D for the two IPM versions.

The results in Table 7 show that the average Q/Ds for the Carlsbad Caverns source grouping are the same for the two IPM versions.

Wichita Mountains Wildlife Refuge, Oklahoma
Figures 14, 15, and 16 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Wichita Mountains Wildlife Refuge, (Wichita Mountains) of Oklahoma. The bar graphs in the figures show that for EGUs in East Texas and the Texas Gulf Coast, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. For EGUs in the West Texas Source region (and for Oklahoma and Kansas as source regions), sulfate and nitrate may have similar contributions to visibility impairment at Wichita Mountains. Overall, for EGUs in the combined Texas source regions and for EGUs in all the United States and international source regions combined, sulfate is the predominant contributor to visibility impairment in this Class I area. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

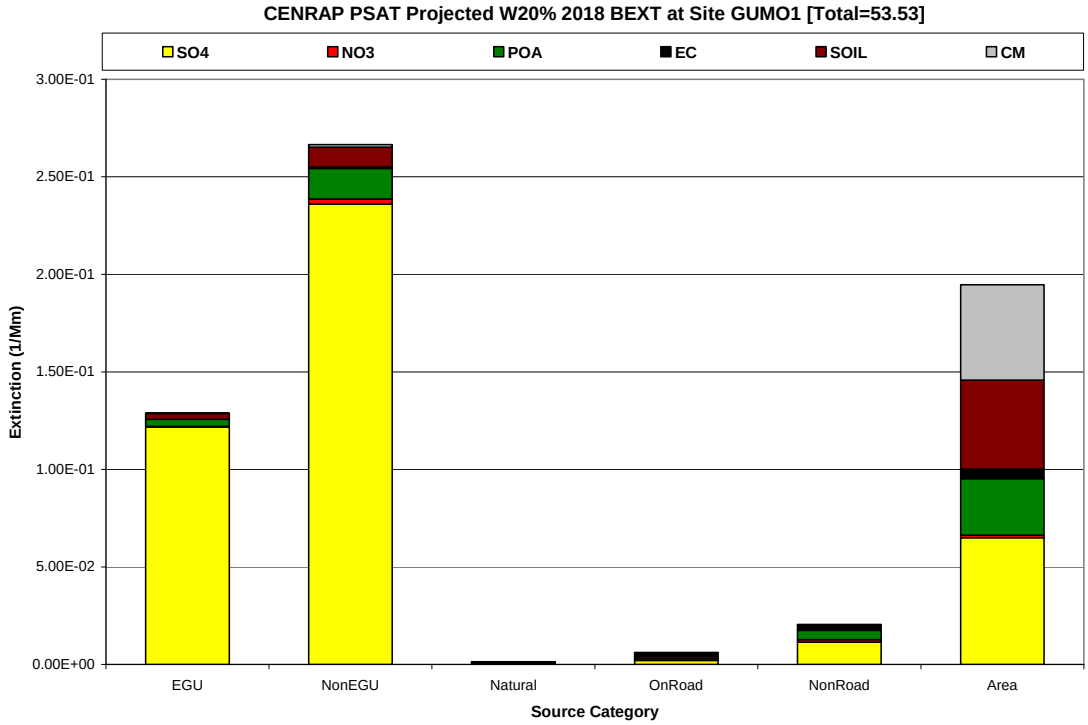
Figure 17 shows the residence time plot for Wichita Mountains. This plot, based on back trajectories from Wichita Mountains, indicates that the SO_2-emitting EGUs located in most of Texas can be grouped for the purposes of calculating an average Q/D for the two IPM versions.

The results in Table 8 show that for the two IPM versions, the average Q/Ds are nearly the same for this Class I area.



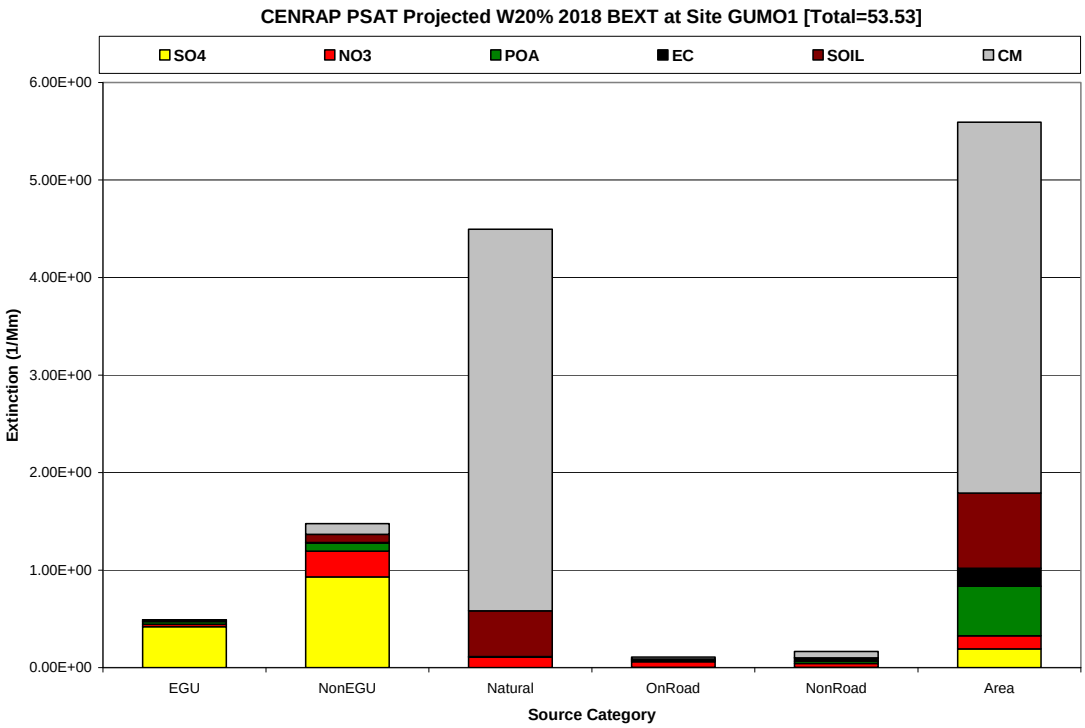
Source: Environ, 2007

Figure 9. Projected Contributions to Light Extinction at Guadalupe Mountains from East Texas Region – 20 Percent Worst Visibility Days – 2018



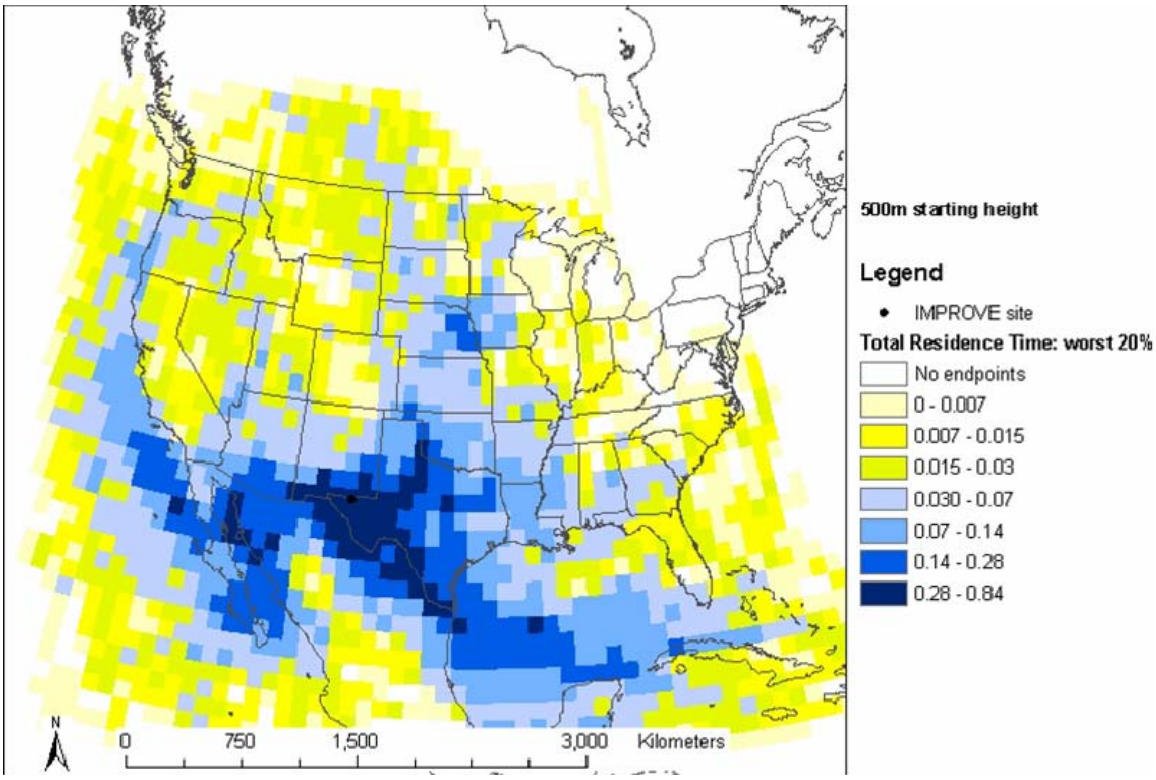
Source: Environ, 2007

Figure 10. Projected Contributions to Light Extinction at Guadalupe Mountains from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 11. Projected Contributions to Light Extinction at Guadalupe Mountains from West Texas Region – 20 Percent Worst Visibility Days – 2018



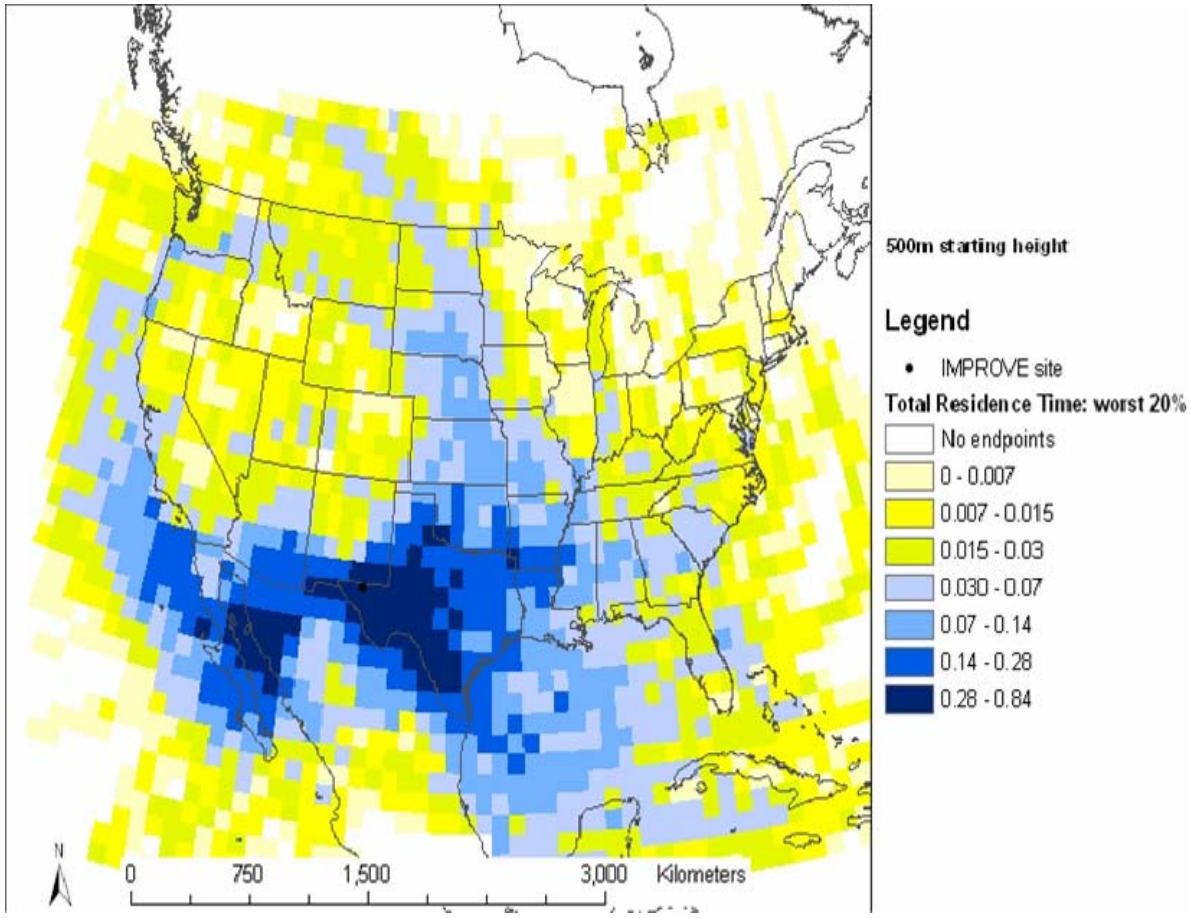
Source: DRI, 2007

Figure 12. Residence Time Plot for Guadalupe Mountains for 20 Percent Worst Visibility Days, Period of Record: 2002-2002

Table 6. Q/D Analysis for Guadalupe Mountains Based on Residence Time Plot

Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	56	32	
Monticello	Titus	55	34	
Martin Lake	Harrison	36	38	
Welsh	Titus	15	37	
Southeast Texas				
W.A. Parish	Fort Bend			
AES Deepwater	Harris			
Mid Coastal Texas				
Coleto Creek	Goliad	20	16	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	3	
Valley				
La Palma	Cameron	0	2	
Central Texas				
Sandow	Milam			
Oak Grove	Robertson	0	19	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	5	5	
Twin Oaks	Robertson			
NRG Limestone	Limestone	21	13	
Gibbons Creek	Grimes			
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	29	6	
South Central Texas				
Deely/Sommers/Spruce	Bexar	40	36	
San Miguel	Atascosa	9	11	
West Central Texas				
San Angelo Power Station	Tom Green	2	0	
North Central Texas				
Oklaunion	Wilbarger	12	11	
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb	65	67	
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**19**	**17**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



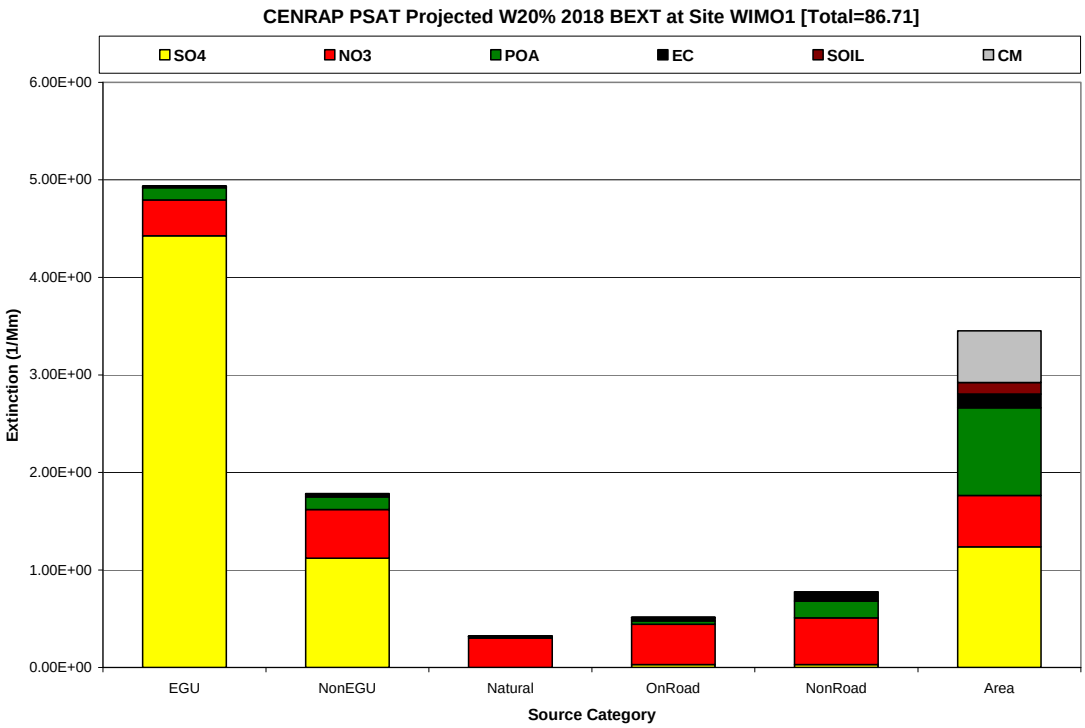
Source: DRI, 2007

Figure 13. Residence Time Plot for Carlsbad Caverns for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 7. Q/D Analysis for Carlsbad Caverns Based on Residence Time Plot

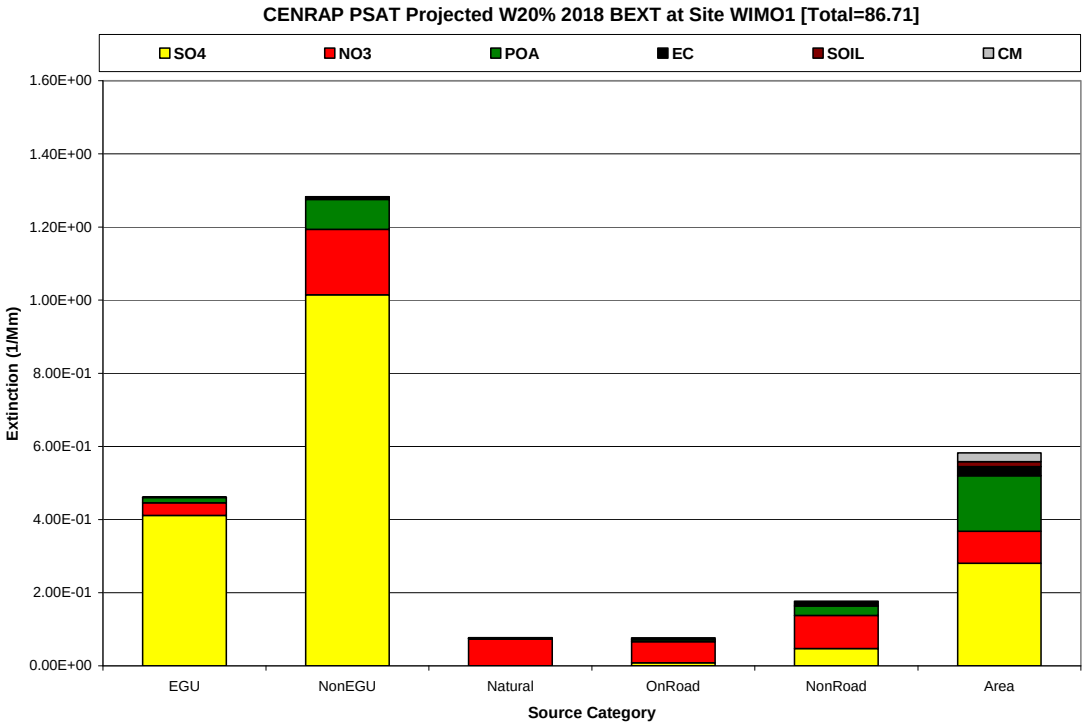
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	56	32	
Monticello	Titus	55	34	
Martin Lake	Harrison	36	38	
Welsh	Titus	15	37	
Pirkey	Harrison	20	13	
Southeast Texas				
W.A. Parish	Fort Bend	17	48	
AES Deepwater	Harris	0	5	
Mid Coastal Texas				
Coleto Creek	Goliad	20	16	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	3	
Valley				
La Palma	Cameron	0	2	
Central Texas				
Sandow	Milam	18	19	
Oak Grove	Robertson	0	19	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	5	5	
Twin Oaks	Robertson	2	1	
NRG Limestone	Limestone	21	13	
Gibbons Creek	Grimes	3	2	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	29	6	
South Central Texas				
Deely/Sommers/ Spruce	Bexar	40	36	
San Miguel	Atascosa	9	11	
West Central Texas				
San Angelo Power Station	Tom Green	2	0	
North Central Texas				
Oklaunion	Wilbarger	12	11	
Panhandle				
Celanese Chemical Manufacturing	Gray	2	1	
Tolk Station	Lamb	65	67	
Harrington Station	Potter	47	48	
Borger Plant and Engineered Carbons Cogen	Hutchinson	0	0	
Overall Average		**17**	**17**	

Note: Values of Q/D are shown only for those SO2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



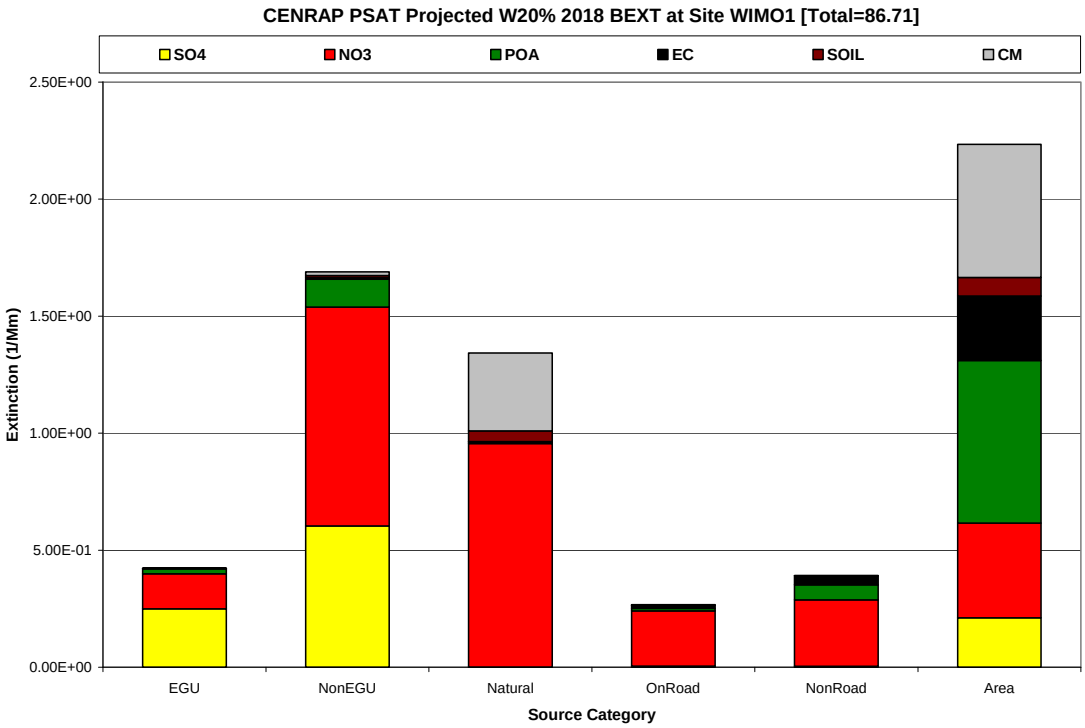
Source: Environ, 2007

Figure 14. Projected Contributions to Light Extinction at Wichita Mountains from East Texas Region – 20 Percent Worst Visibility Days –- 2018



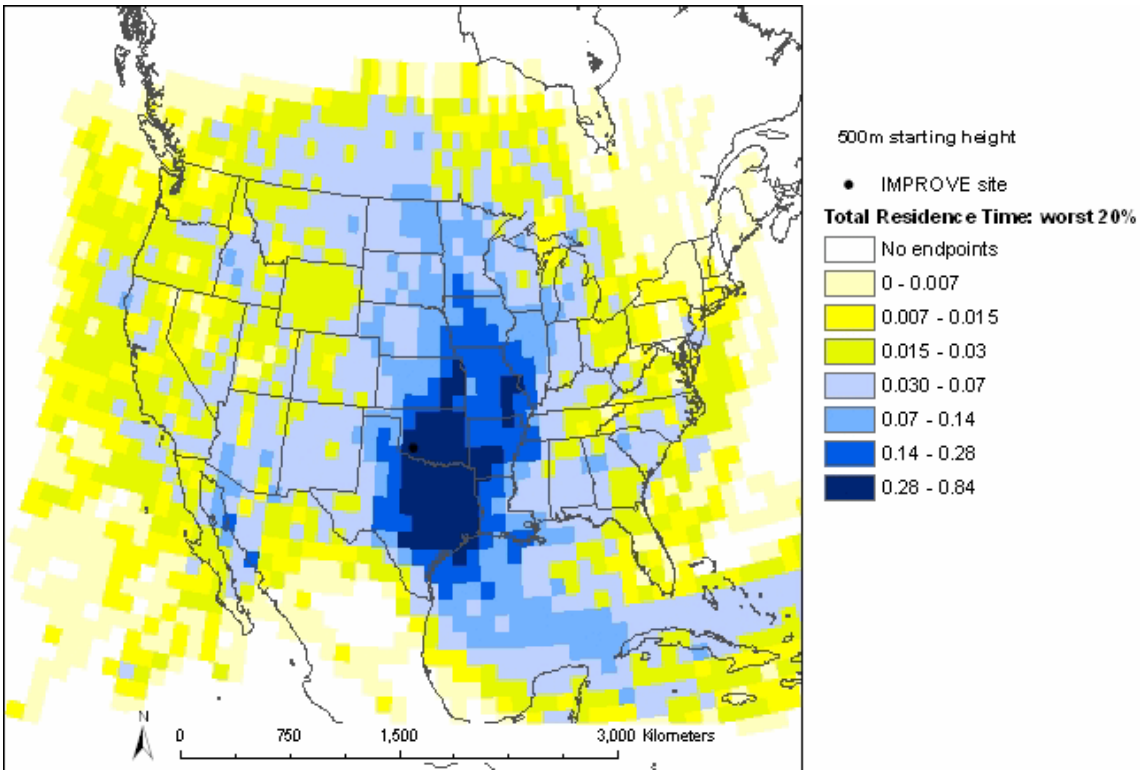
Source: Environ, 2007

Figure 15. Projected Contributions to Light Extinction at Wichita Mountains from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 16. Projected Contributions to Light Extinction at Wichita Mountains from West Texas Region – 20 Percent Worst Visibility Days – 2018



Source: DRI, 2007

Figure 17. Residence Time Plot for Wichita Mountains for 20 Percent Worst Visibility Days, Period of Record: 2002-2004

Table 8. Q/D Analysis for Wichita Mountains Based on Residence Time Plot

Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	117	67	
Monticello	Titus	133	82	
Martin Lake	Harrison	76	79	
Welsh	Titus	35	89	
Pirkey	Harrison	42	28	
Southeast Texas				
W.A. Parish	Fort Bend	24	69	
AES Deepwater	Harris	0	7	
Mid Coastal Texas				
Coleto Creek	Goliad	24	20	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	4	
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam	28	30	
Oak Grove	Robertson	0	32	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	9	9	
Twin Oaks	Robertson	4	2	
NRG Limestone	Limestone	42	25	
Gibbons Creek	Grimes	5	4	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	41	9	
South Central Texas				
Deely/Sommers/ Spruce	Bexar	47	41	
San Miguel	Atascosa	10	12	
West Central Texas				
San Angelo Power Station	Tom Green	2	0	
North Central Texas				
Oklaunion	Wilbarger	79	73	
Panhandle				
Celanese Chemical Manufacturing	Gray	5	3	
Tolk Station	Lamb			
Harrington Station	Potter	80	81	
Borger Plant and Engineered Carbons Cogen	Hutchinson	0	0	
Overall Average		**31**	**30**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.

Caney Creek Wilderness Area, Arkansas
Figures 18, 19, and 20 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Caney Creek Wilderness Area (Caney Creek) of Arkansas. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when states surrounding Arkansas are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Caney Creek. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

Figure 21 shows the residence time plot for Caney Creek. This plot indicates that the SO_2-emitting EGUs located in eastern Texas and parts of central Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 9 show that for this Class I area, the average Q/D for IPM Version 2.19 is slightly greater than that for IPM Version 3.0.

Upper Buffalo Wilderness Area, Arkansas
Figures 22, 23, and 24 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Upper Buffalo Wilderness Area (Upper Buffalo) of Arkansas. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when states surrounding Arkansas are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Upper Buffalo. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

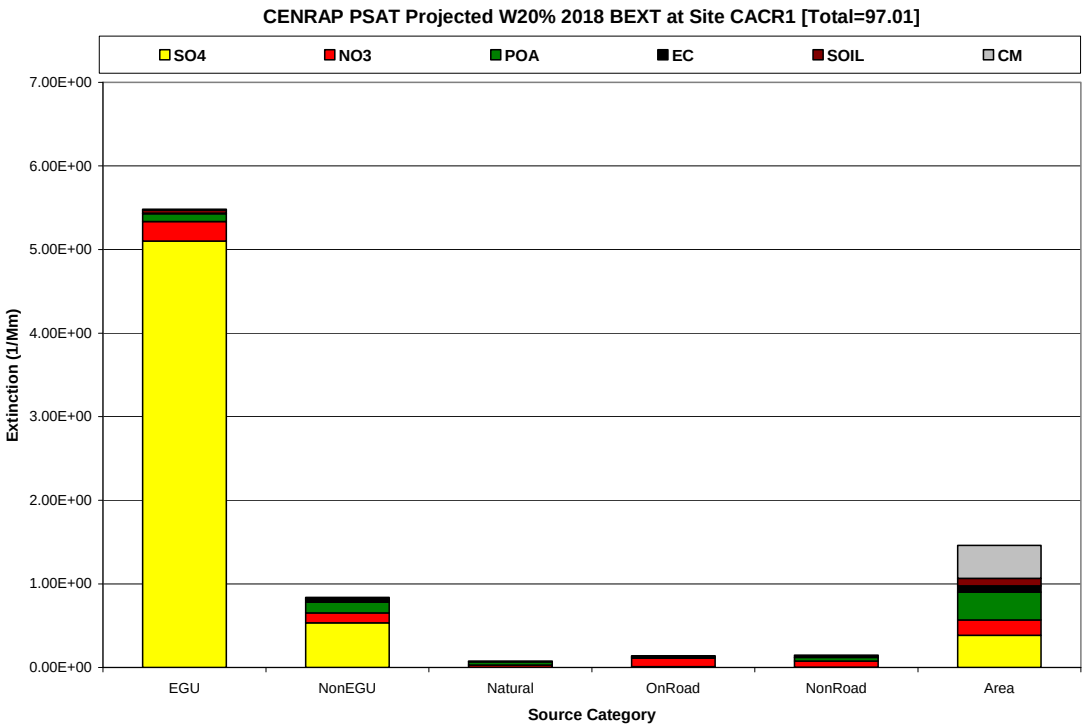
Figure 25 shows the residence time plot for Upper Buffalo. This plot indicates that the SO_2-emitting EGUs located in eastern Texas and eastern parts of central Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 10 show that for this Class I area, the average Q/Ds for IPM Versions 2.19 and 3.0 are the same.

Hercules Glades Wilderness Area, Missouri
Figures 26, 27, and 28 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Hercules Glades Wilderness Area (Hercules Glades) of Missouri. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when states surrounding Missouri are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Hercules Glades. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

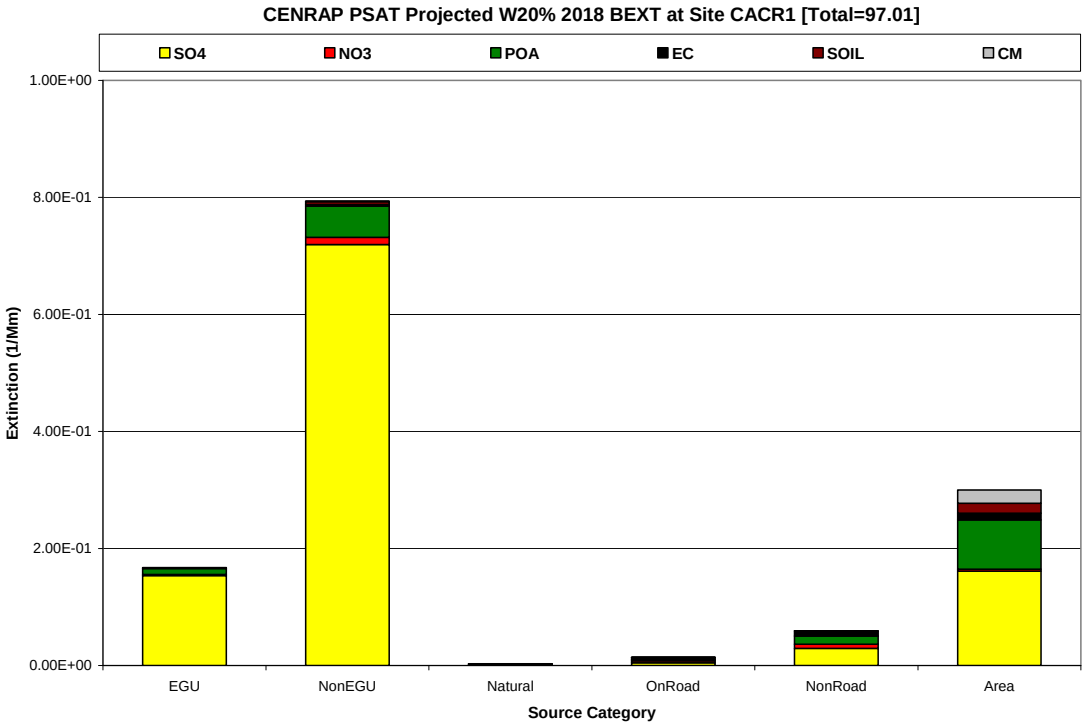
Figure 29 shows the residence time plot for Hercules Glades. This plot indicates that the SO_2-emitting EGUs located in eastern Texas and eastern parts of central Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 11 show that for this Class I area, the average Q/Ds for IPM Versions 2.19 and 3.0 are nearly the same.



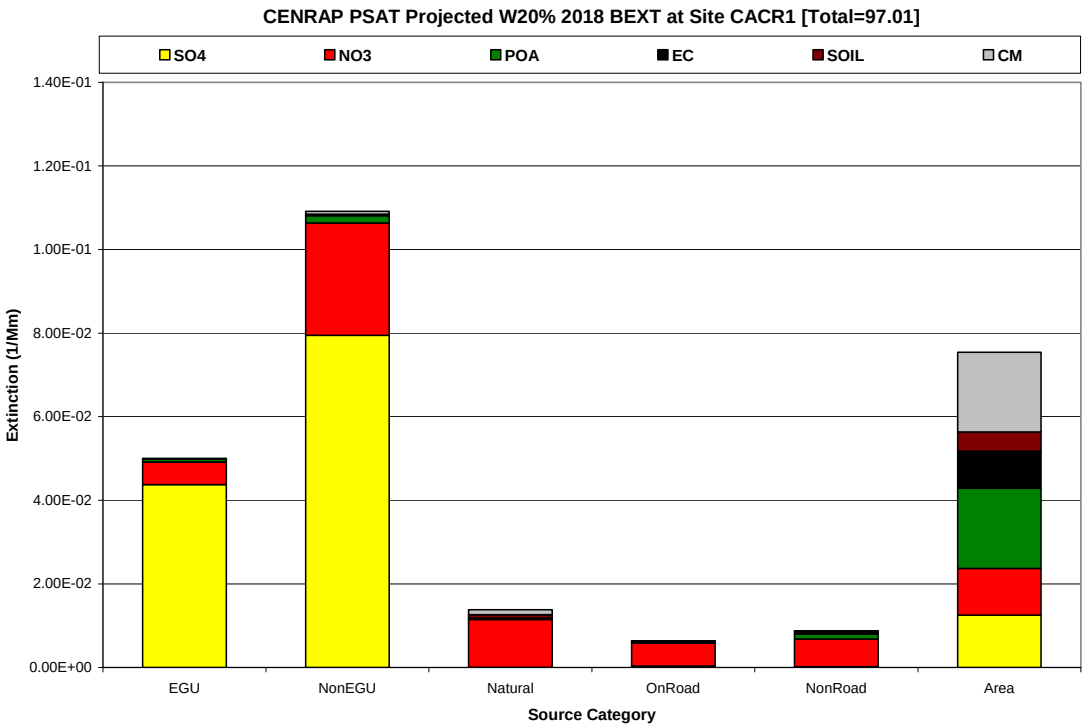
Source: Environ, 2007

Figure 18. Projected Contributions to Light Extinction at Caney Creek from East Texas Region – 20 Percent Worst Visibility Days – 2018



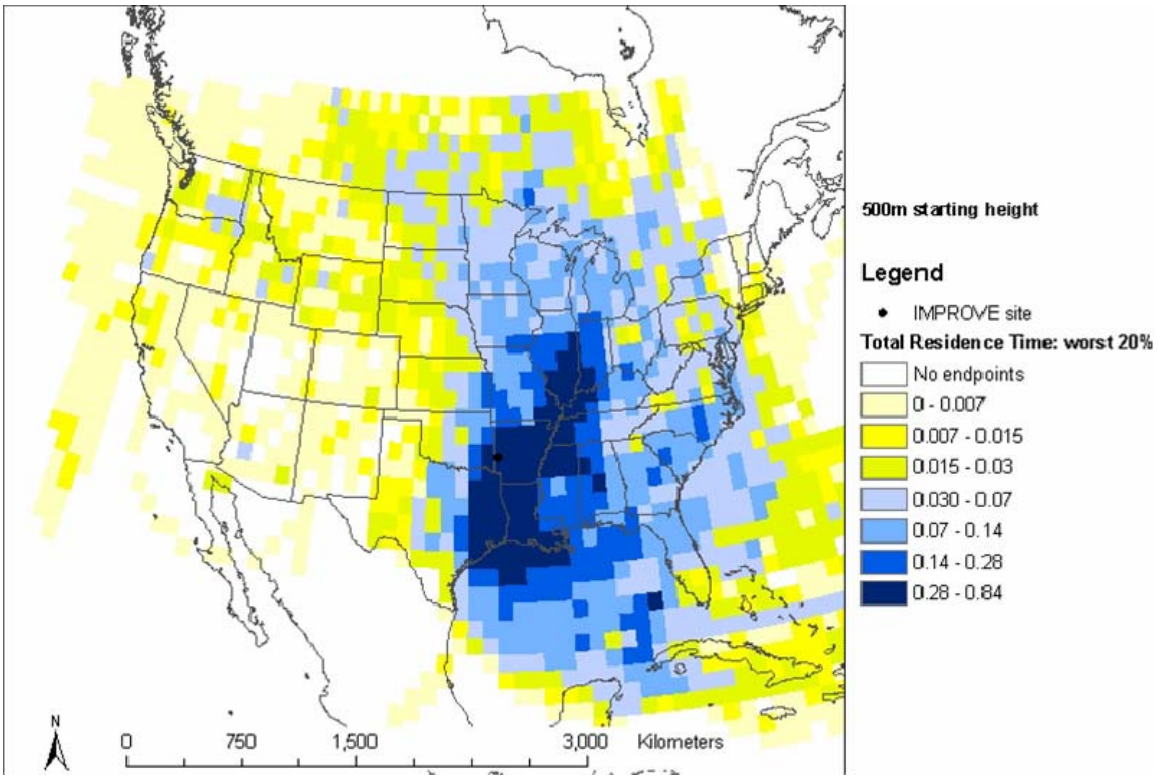
Source: Environ, 2007

Figure 19. Projected Contributions to Light Extinction at Caney Creek from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 20. Projected Contributions to Light Extinction at Caney Creek from West Texas Region – 20 Percent Worst Visibility Days – 2018



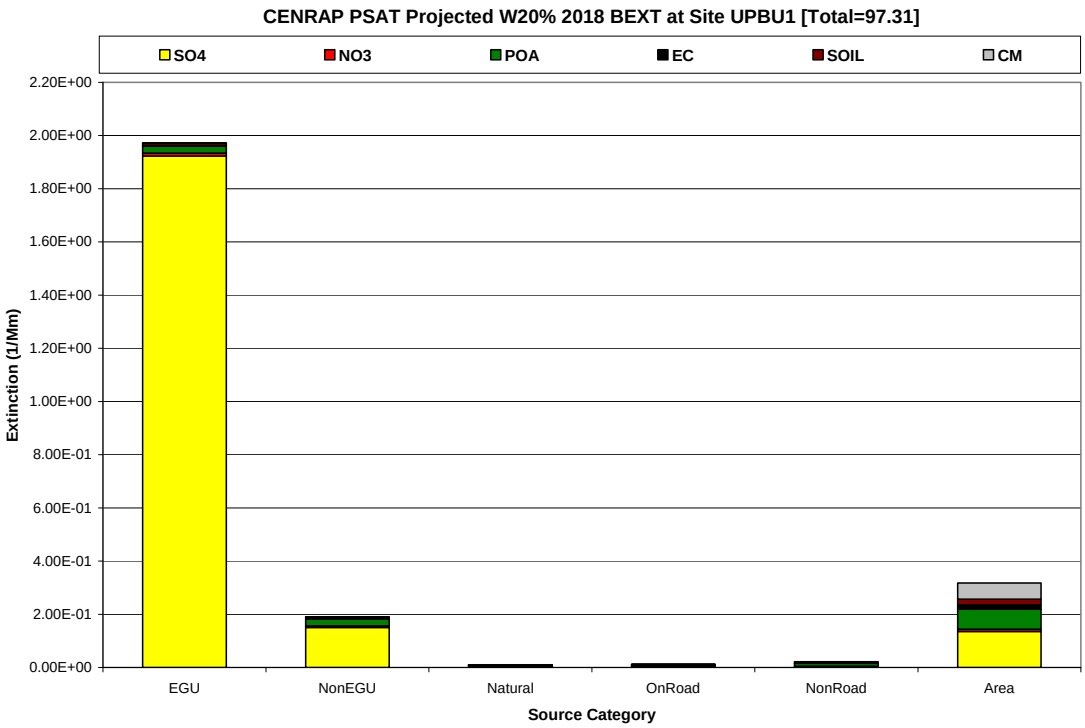
Source: DRI, 2007

Figure 21. Residence Time Plot for Caney Creek for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 9. Q/D Analysis for Caney Creek Based on Residence Time Plot

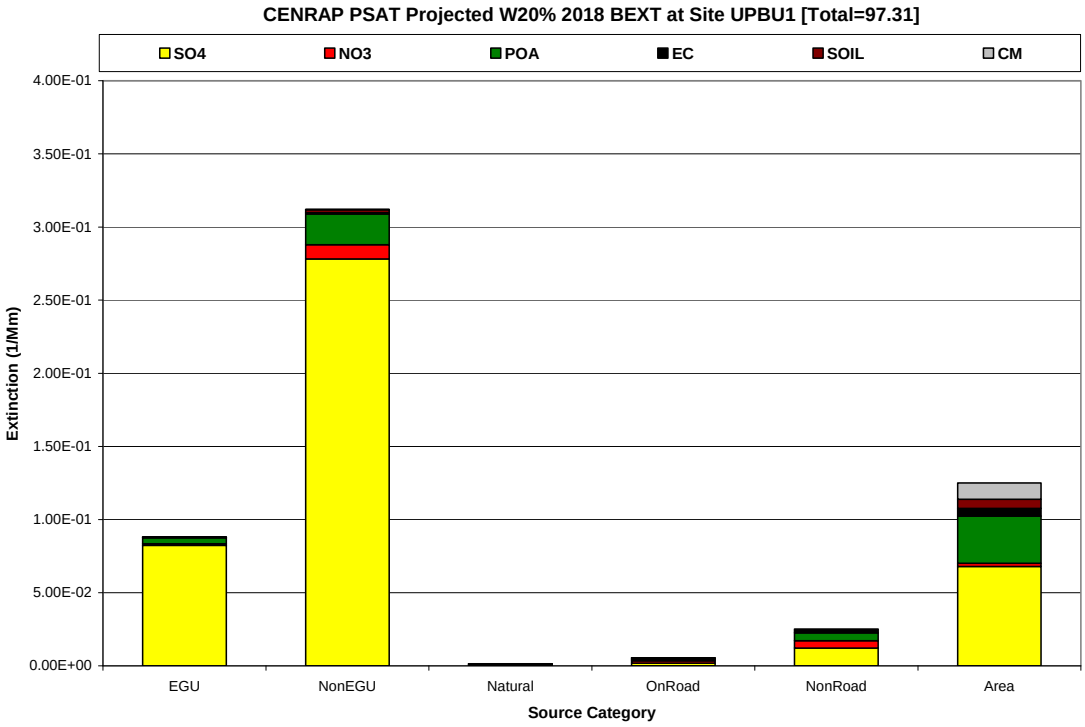
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	134	77	
Monticello	Titus	287	178	
Martin Lake	Harrison	143	148	
Welsh	Titus	81	203	
Pirkey	Harrison	85	57	
Southeast Texas				
W.A. Parish	Fort Bend	27	78	
AES Deepwater	Harris	0	9	
Mid Coastal Texas				
Coleto Creek	Goliad			
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	4	
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam	26	28	
Oak Grove	Robertson	0	32	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan			
Twin Oaks	Robertson	4	2	
NRG Limestone	Limestone	44	27	
Gibbons Creek	Grimes	6	4	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	41	9	
South Central Texas				
Deely/Sommers/Spruce	Bexar			
San Miguel	Atascosa			
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb			
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**52**	**50**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



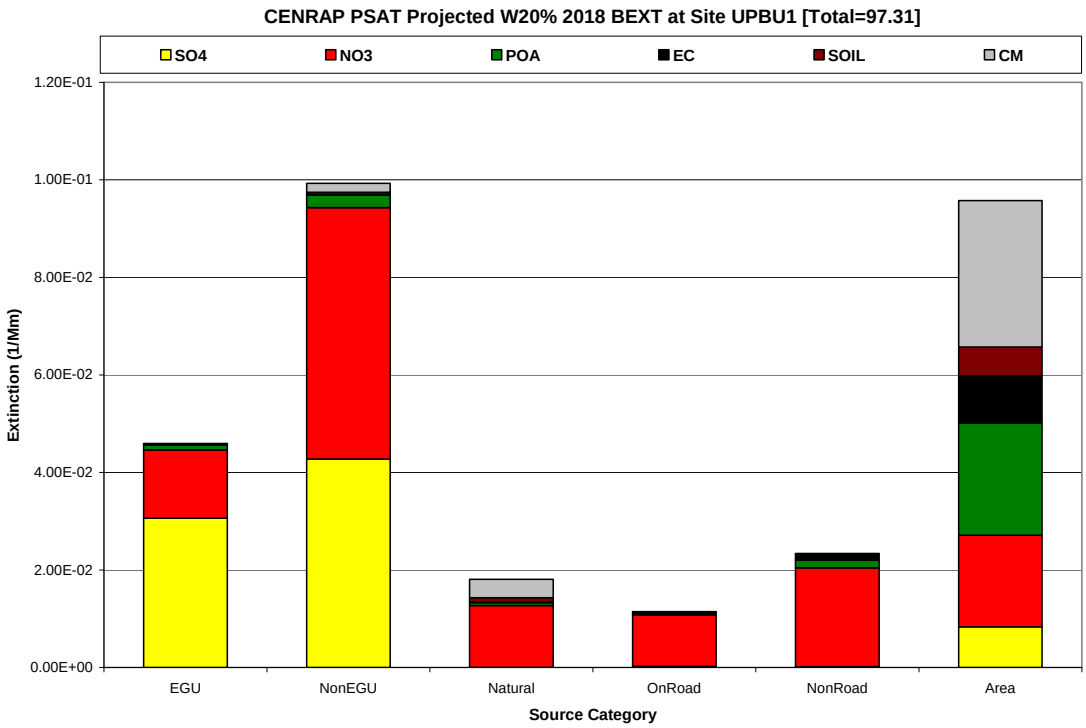
Source: Environ, 2007

Figure 22. Projected Contributions to Light Extinction at Upper Buffalo from East Texas Region – 20 Percent Worst Visibility Days – 2018



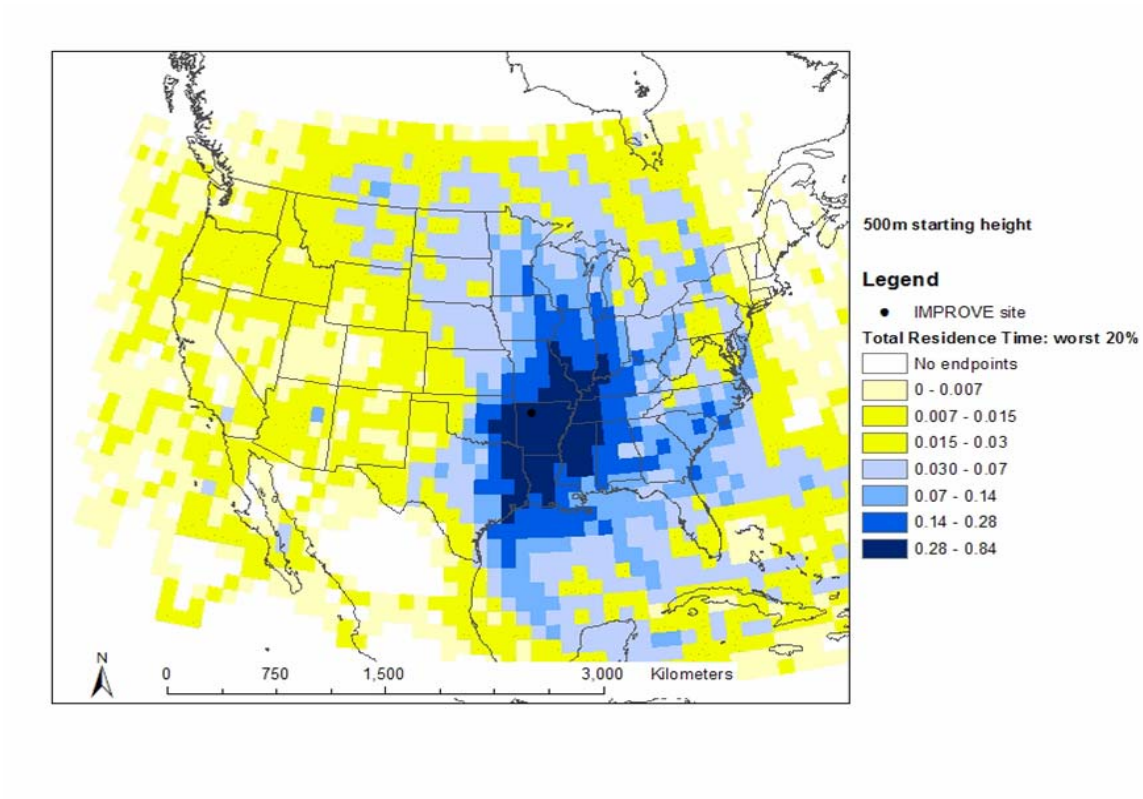
Source: Environ, 2007

Figure 23. Projected Contributions to Light Extinction at Upper Buffalo from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 24. Projected Contributions to Light Extinction at Upper Buffalo from West Texas Region – 20 Percent Worst Visibility Days – 2018



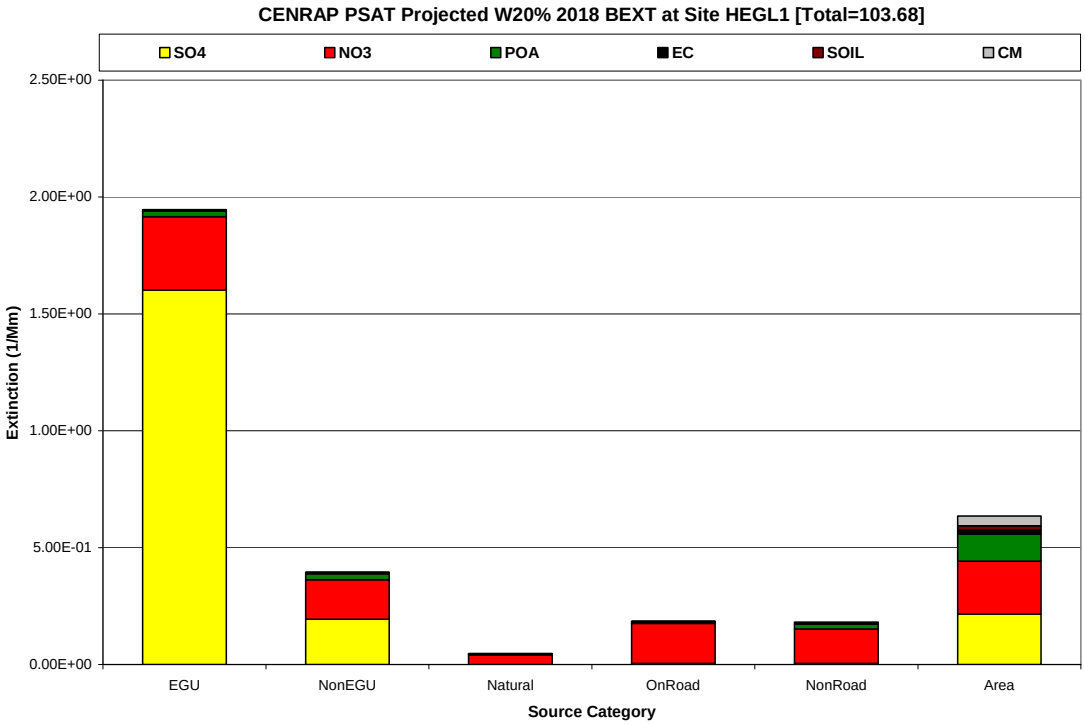
Source: DRI, 2007

Figure 25. Residence Time Plot for Upper Buffalo for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 10. Q/D Analysis for Upper Buffalo Based on Residence Time Plot

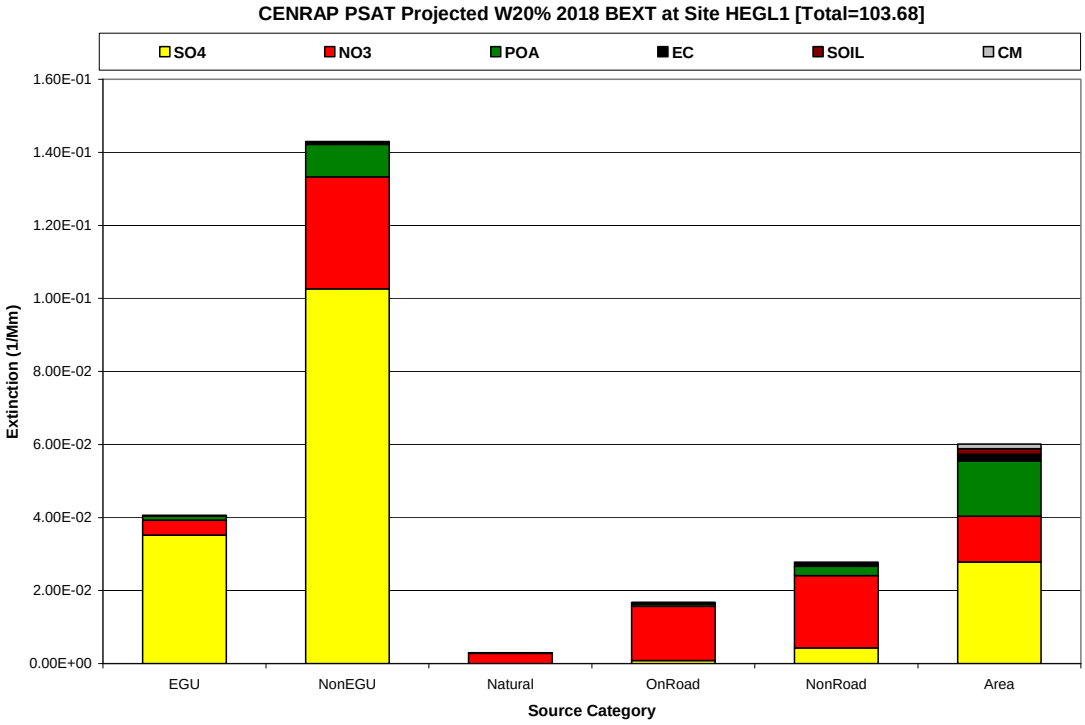
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	91	52	
Monticello	Titus	150	93	
Martin Lake	Harrison	86	89	
Welsh	Titus	42	104	
Pirkey	Harrison	49	33	
Southeast Texas				
W.A. Parish	Fort Bend	21	60	
AES Deepwater	Harris	0	7	
Mid Coastal Texas				
Coleto Creek	Goliad			
BP Chemicals Green Lake	Calhoun			
Formosa Plastics	Calhoun			
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam	20	21	
Oak Grove	Robertson	0	25	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	6	6	
Twin Oaks	Robertson	3	2	
NRG Limestone	Limestone	31	19	
Gibbons Creek	Grimes	4	3	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette			
South Central Texas				
Deely/Sommers/Spruce	Bexar			
San Miguel	Atascosa			
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb			
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**34**	**34**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



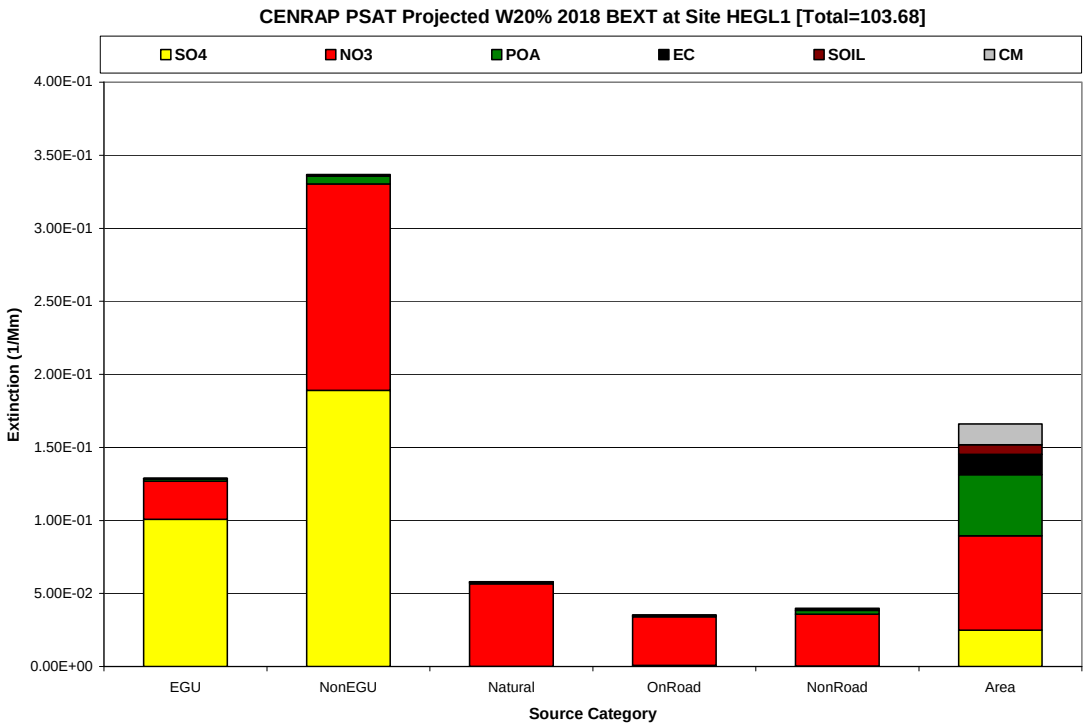
Source: Environ, 2007

Figure 26. Projected Contributions to Light Extinction at Hercules Glades from East Texas Region – 20 Percent Worst Visibility Days – 2018



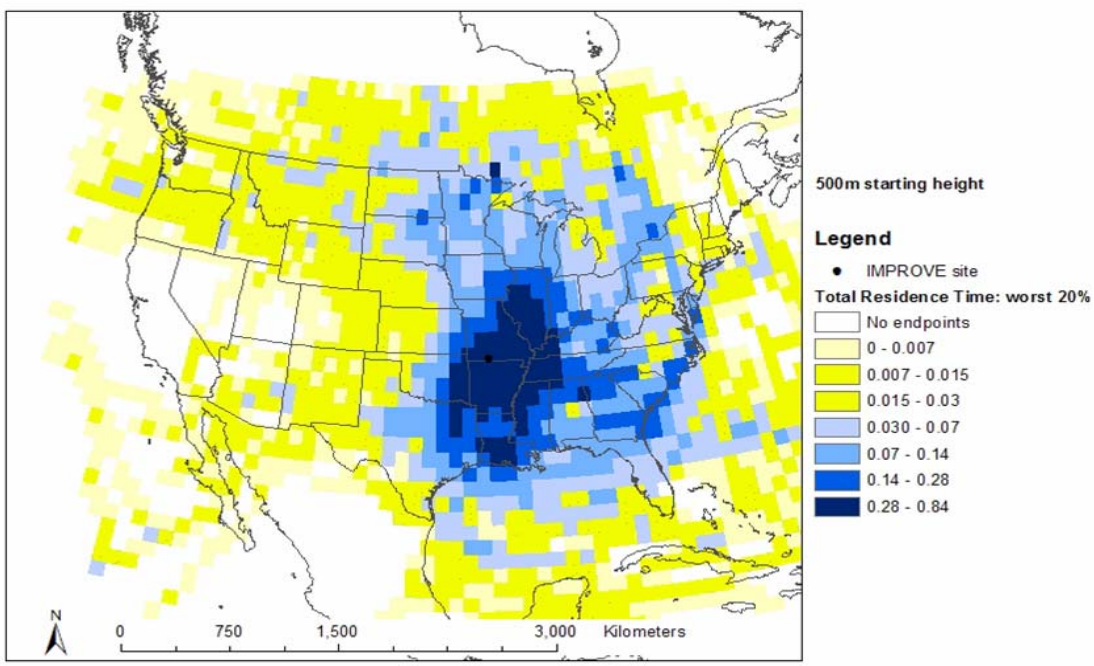
Source: Environ, 2007

Figure 27. Projected Contributions to Light Extinction at Hercules Glades from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 28. Projected Contributions to Light Extinction at Hercules Glades from West Texas Region – 20 Percent Worst Visibility Days – 2018



Source: DRI, 2007

Figure 29. Residence Time Plot for Hercules Glades for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 11. Q/D Analysis for Hercules Glades Based on Residence Time Plot

Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	77	44	
Monticello	Titus	118	73	
Martin Lake	Harrison	70	72	
Welsh	Titus	32	81	
Pirkey	Harrison	40	27	
Southeast Texas				
W.A. Parish	Fort Bend	18	54	
AES Deepwater	Harris	0	6	
Mid Coastal Texas				
Coleto Creek	Goliad			
BP Chemicals Green Lake	Calhoun			
Formosa Plastics	Calhoun			
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam	18	19	
Oak Grove	Robertson	0	22	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	5	5	
Twin Oaks	Robertson	2	1	
NRG Limestone	Limestone	27	16	
Gibbons Creek	Grimes	4	3	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette			
South Central Texas				
Deely/Sommers/Spruce	Bexar			
San Miguel	Atascosa			
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb			
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**27**	**28**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.

Breton Island National Wilderness Area, Louisiana
Figures 30, 31, and 32 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Breton Island National Wilderness Area (Breton Island) of Louisiana. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when states surrounding Louisiana are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at Breton Island. Thus, as with previously discussed Class I areas, TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

Figure 33 shows the residence time plot for Breton Island. This plot indicates that the SO_2-emitting EGUs located in eastern Texas and eastern portions of central Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

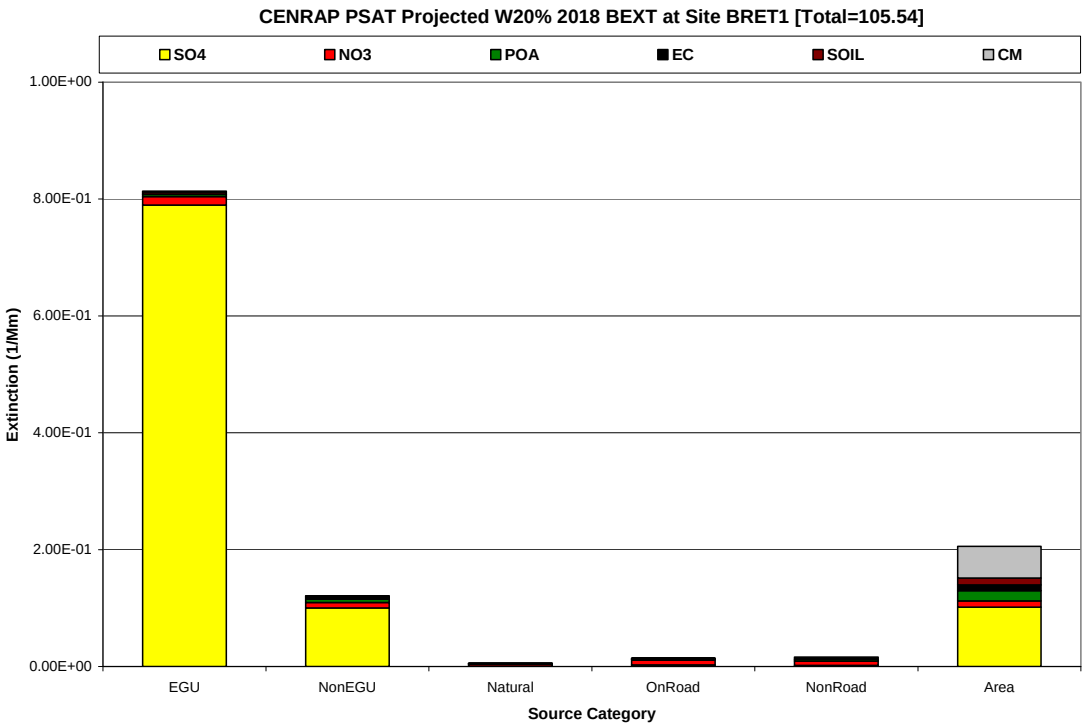
The results in Table 12 show that for this Class I area, the average Q/Ds for the two IPM versions are nearly the same.

Salt Creek Wilderness Area, New Mexico
Figures 34, 35, and 36 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the Salt Creek Wilderness Area (Salt Creek) of New Mexico. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when other states surrounding Salt Creek are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at this Class I area. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

Figure 37 shows the residence time plot for Salt Creek. This plot indicates that the SO_2-emitting EGUs located in most of Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

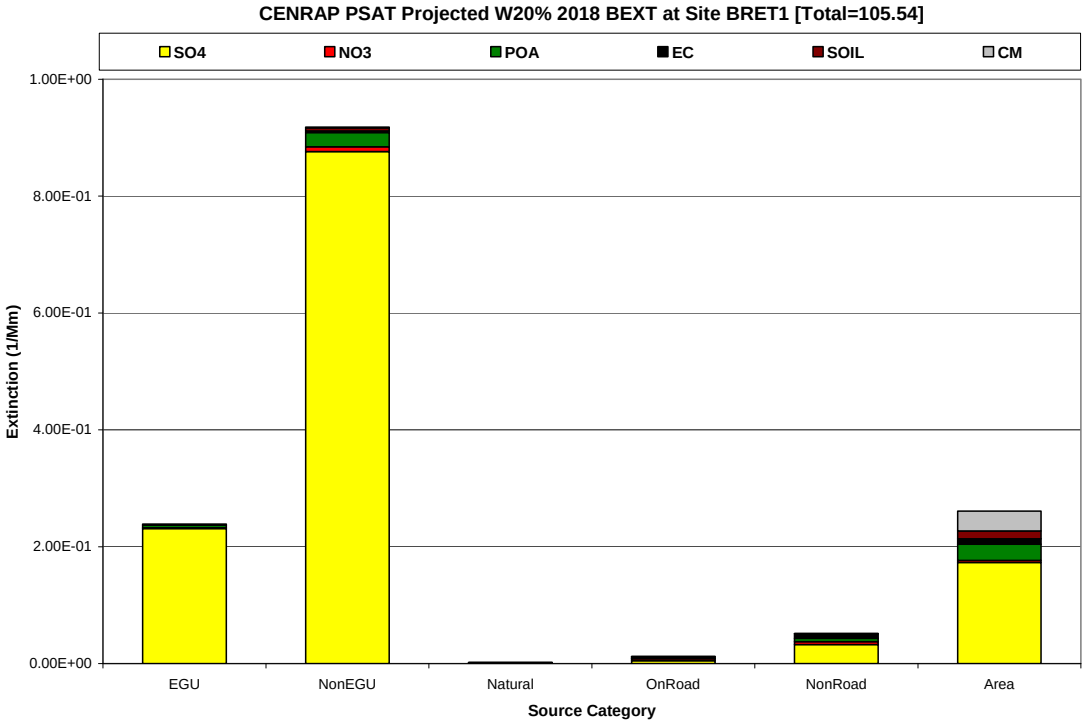
The results in Table 13 show that for this Class I area, the average Q/Ds for the two IPM versions are nearly the same.

White Mountain Wilderness Area, New Mexico
Figures 38, 39, and 40 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment in the White Mountain Wilderness Area (White Mountain) of New Mexico. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when other states surrounding White Mountain are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at this Class I area. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.



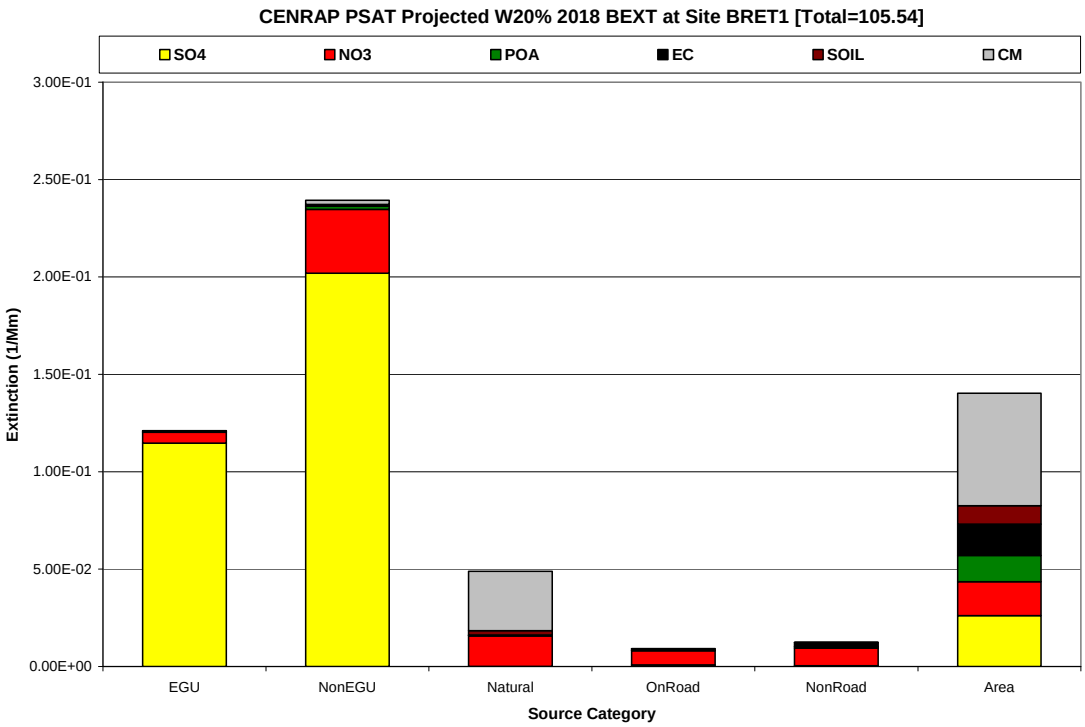
Source: Environ, 2007

Figure 30. Projected Contributions to Light Extinction at Breton Island from East Texas Region – 20 Percent Worst Visibility Days – 2018



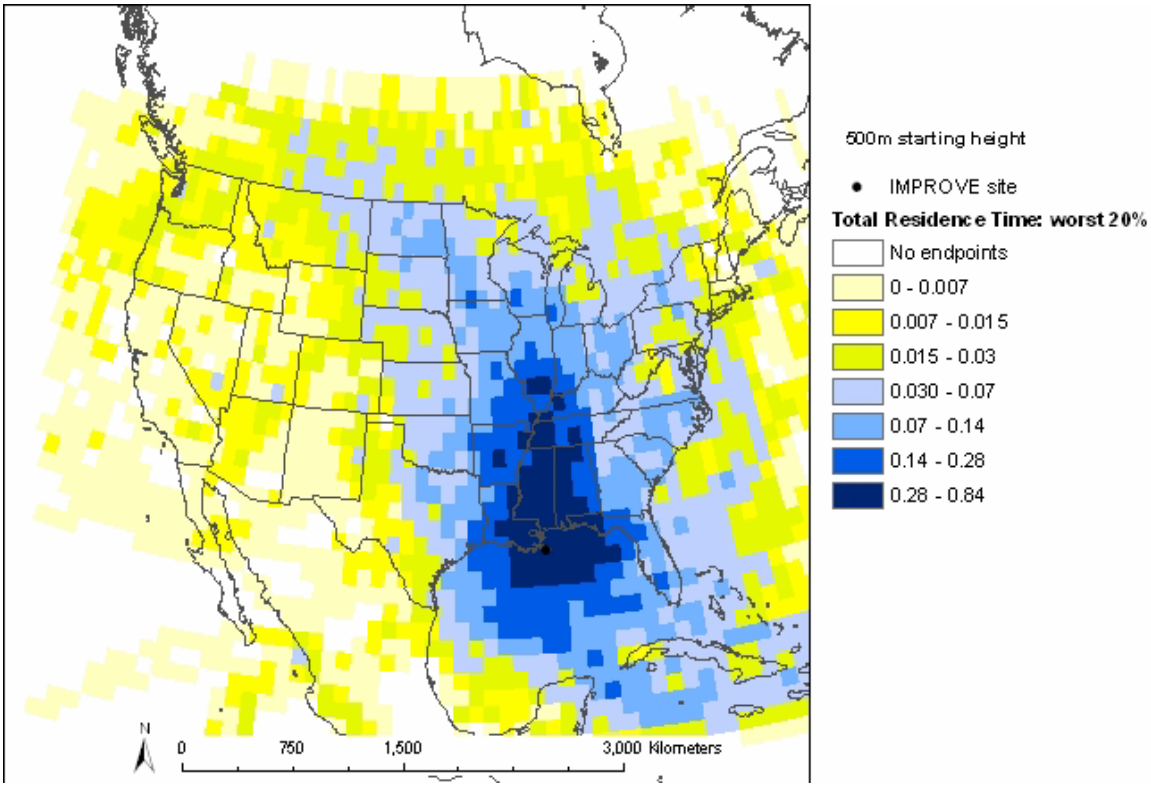
Source: Environ, 2007

Figure 31. Projected Contributions to Light Extinction at Breton Island from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 32. Projected Contributions to Light Extinction at Breton Island from West Texas Region – 20 Percent Worst Visibility Days – 2018



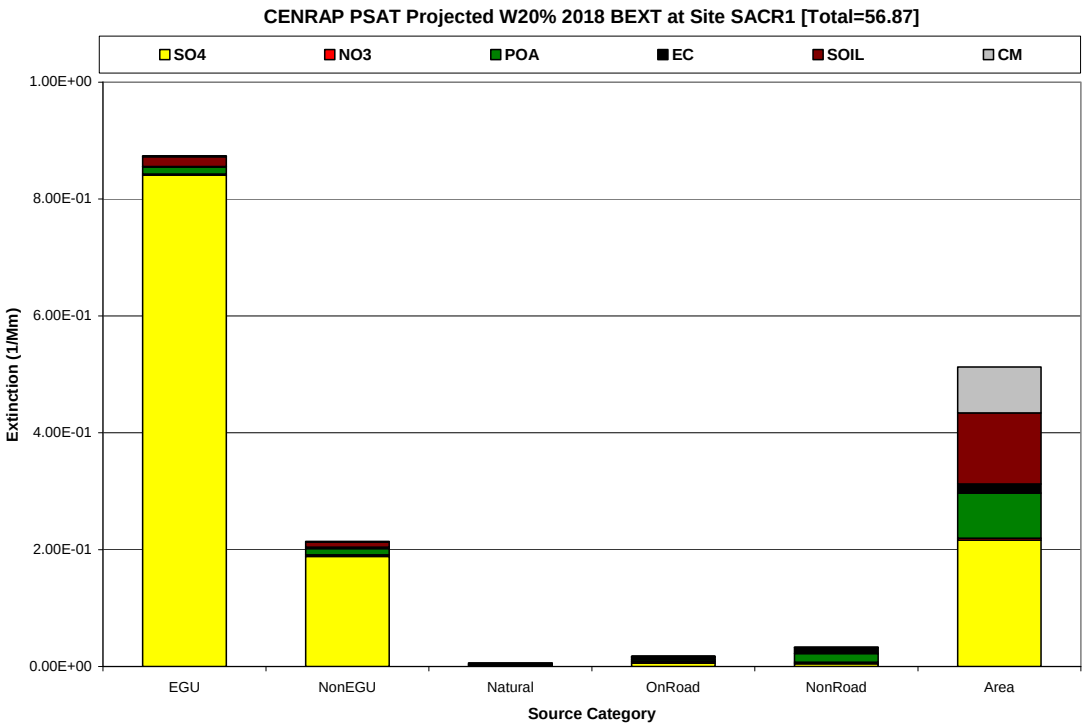
Source: DRI, 2007

Figure 33. Residence Time Plot for Breton Island for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 12. Q/D Analysis for Breton Island Based on Residence Time Plot

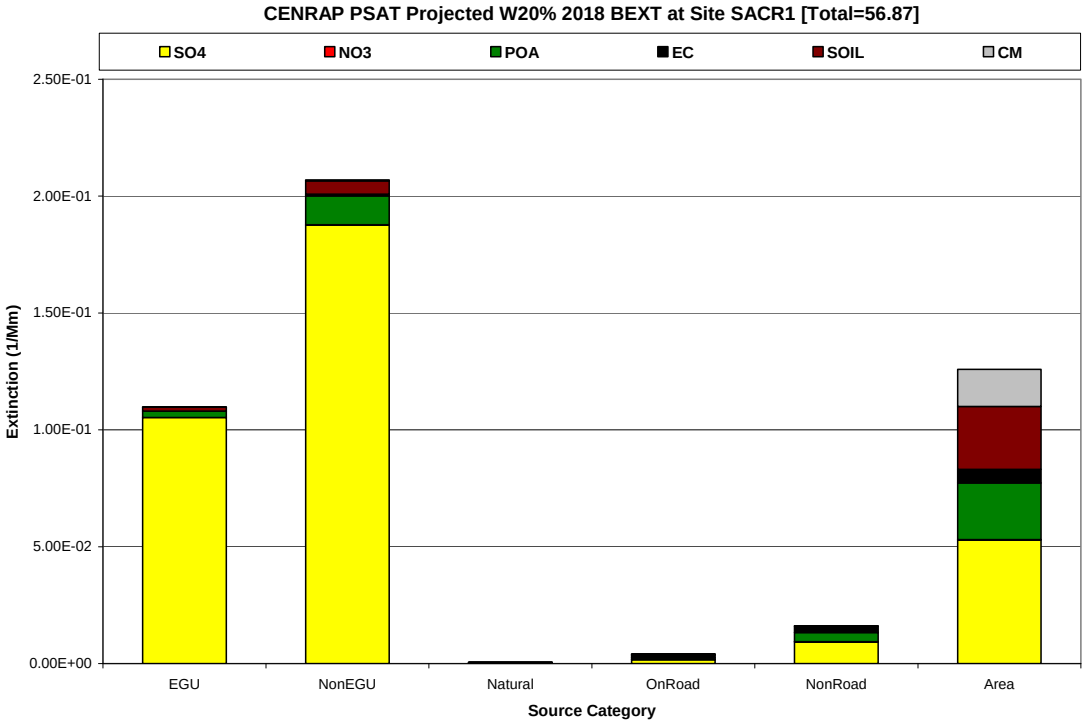
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone	65	37	
Monticello	Titus	75	47	
Martin Lake	Harrison	60	62	
Welsh	Titus	21	53	
Pirkey	Harrison	32	21	
Southeast Texas				
W.A. Parish	Fort Bend	23	68	
AES Deepwater	Harris	0	8	
Mid Coastal Texas				
Coleto Creek	Goliad			
BP Chemicals Green Lake	Calhoun			
Formosa Plastics	Calhoun			
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam	17	18	
Oak Grove	Robertson	0	20	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	5	5	
Twin Oaks	Robertson	2	1	
NRG Limestone	Limestone	24	15	
Gibbons Creek	Grimes	4	3	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	30	6	
South Central Texas				
Deely/Sommers/Spruce	Bexar			
San Miguel	Atascosa			
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb			
Harrington Station	Potter			
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**22**	**23**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



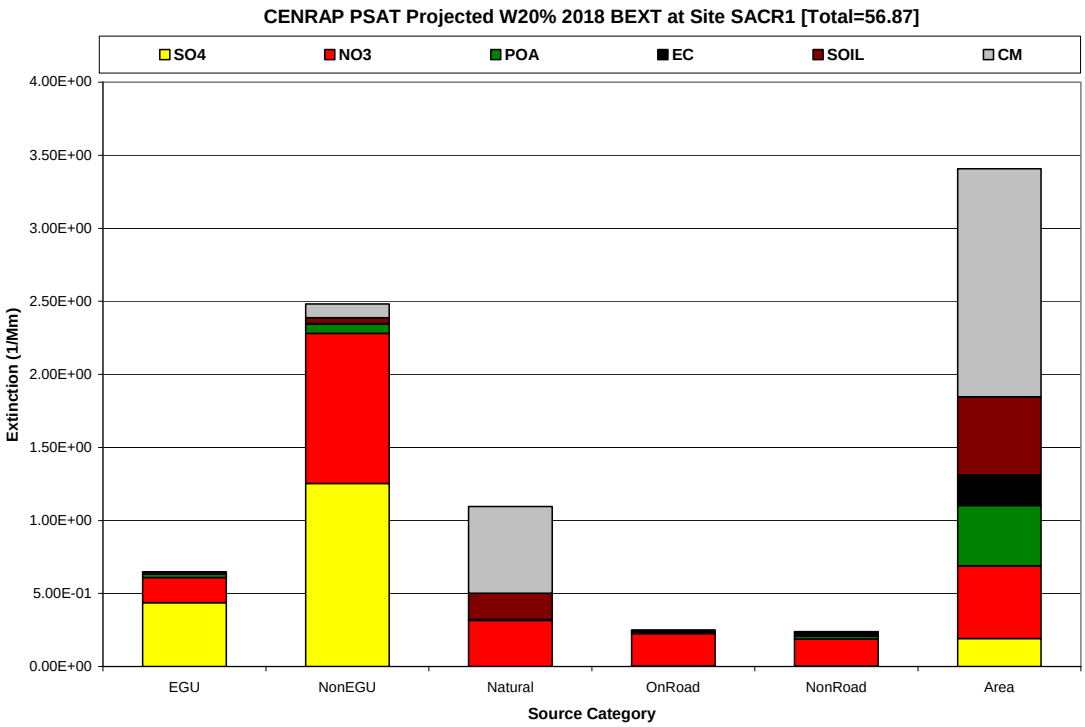
Source: Environ, 2007

Figure 34. Projected Contributions to Light Extinction at Salt Creek from East Texas Region – 20 Percent Worst Visibility Days – 2018



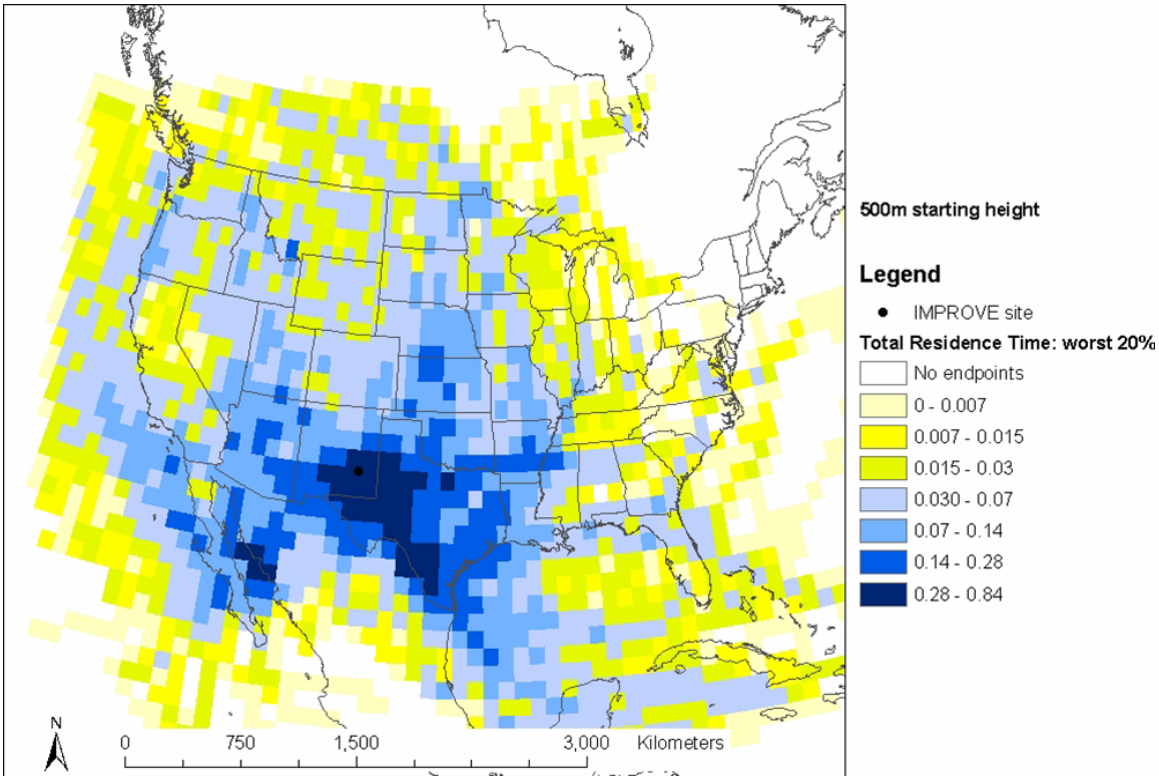
Source: Environ, 2007

Figure 35. Projected Contributions to Light Extinction at Salt Creek from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 36. Projected Contributions to Light Extinction at Salt Creek from West Texas Region – 20 Percent Worst Visibility Days – 2018



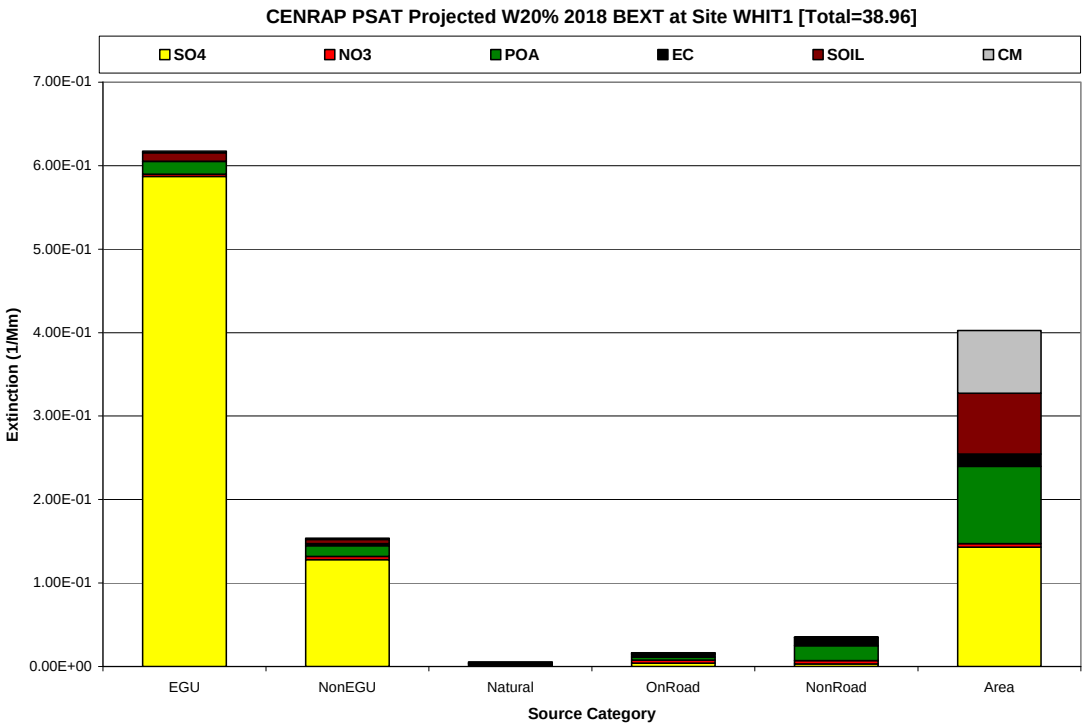
Source: DRI, 2007

Figure 37. Residence Time Plot for Salt Creek for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 13. Q/D Analysis for Salt Creek Based on Residence Time Plot

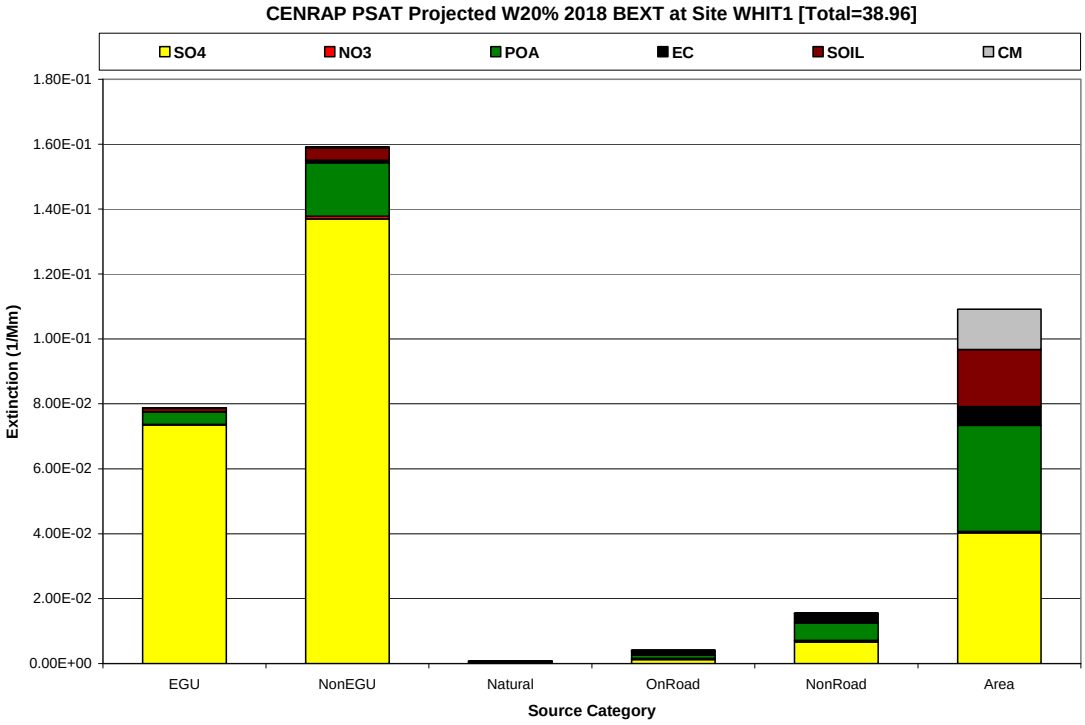
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone			
Monticello	Titus			
Martin Lake	Harrison	38	39	
Welsh	Titus			
Pirkey	Harrison	21	14	
Southeast Texas				
W.A. Parish	Fort Bend	16	47	
AES Deepwater	Harris	0	5	
Mid Coastal Texas				
Coleto Creek	Goliad	18	15	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	3	
Valley				
La Palma	Cameron	0	1	
Central Texas				
Sandow	Milam	18	19	
Oak Grove	Robertson	0	19	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	5	5	
Twin Oaks	Robertson			
NRG Limestone	Limestone	22	13	
Gibbons Creek	Grimes	3	2	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	28	6	
South Central Texas				
Deely/Sommers/Spruce	Bexar	37	33	
San Miguel	Atascosa	8	10	
West Central Texas				
San Angelo Power Station	Tom Green	2	0	
North Central Texas				
Oklaunion	Wilbarger	14	13	
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb	113	118	
Harrington Station	Potter	70	71	
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**19**	**20**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



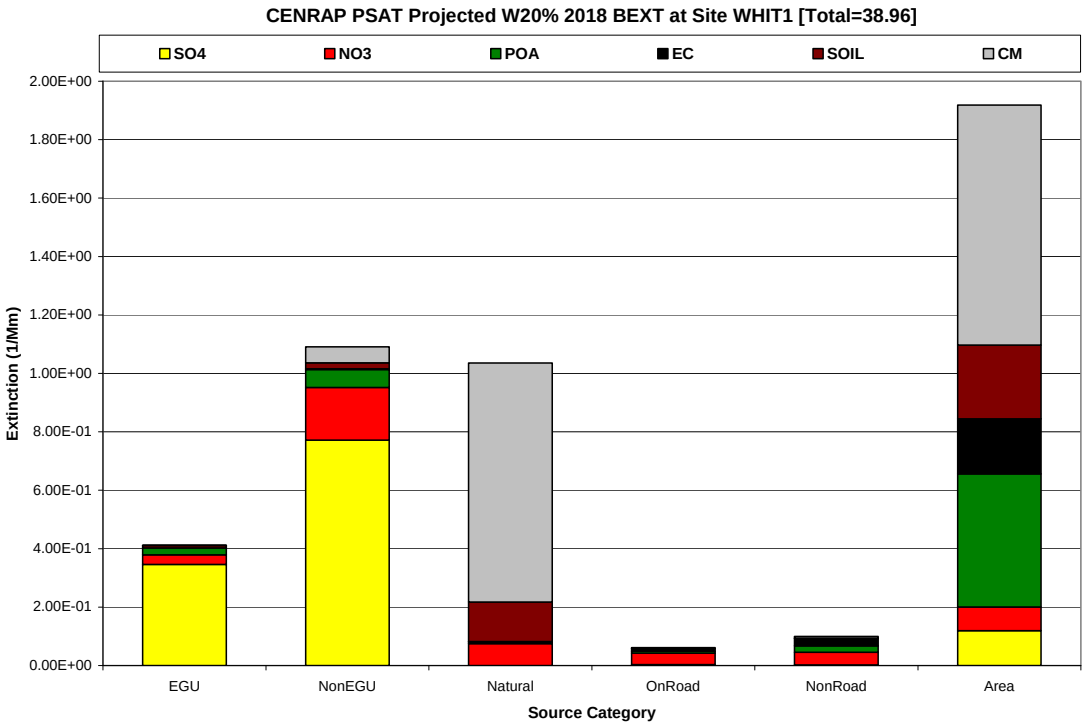
Source: Environ, 2007

Figure 38. Projected Contributions to Light Extinction at White Mountain from East Texas Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 39. Projected Contributions to Light Extinction at White Mountain from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 40. Projected Contributions to Light Extinction at White Mountain from West Texas Region – 20 Percent Worst Visibility Days – 2018

No residence time plot was available for White Mountain. However, White Mountain is very close to Salt Creek, so the TCEQ reviewed the residence time plot for Salt Creek. This plot indicates that the SO_2-emitting EGUs located in most of Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 14 show that for this Class I area, the Q/Ds are nearly the same for both IPM versions.

Great Sand Dunes National Monument, Colorado

Figures 41, 42, and 43 show the projected contribution of various source categories and pollutant components to 2018 visibility impairment at the Great Sand Dunes National Monument (Great Sand Dunes) of Colorado. The bar graphs show that for EGUs in Texas, sulfate is predicted by PSAT to be the predominant pollutant component causing visibility impairment in this Class I area. PSAT results also show that when other states surrounding Great Sand Dunes are viewed as EGU emission source regions, sulfate is the main pollutant component contributing to visibility impairment at this Class I area. Thus, the TCEQ focused on SO_2 emissions from EGUs in the comparison of IPM Versions 2.19 and 3.0 for this area.

Figure 44 shows the residence time plot for Great Sand Dunes. Based on this plot, EGUs in portions of the western half of Texas can be grouped for the purposes of calculating average Q/Ds for the two IPM versions.

The results in Table 15 show that for this Class I area, the average Q/Ds for the two IPM versions are the same.

Uncertainties in the IPM and the IPM Analysis

Due to the fact that the IPM is based on a large number of economic, policy, and logistics factors influencing the extent and types of predicted electric generating capacity, large uncertainties are inherent in the model. The uncertainty in the model is clearly demonstrated by the fact that assumptions about the costs of natural gas were outdated soon after the results of the IPM Version 2.19 were released. However, there is no certainty that the assumptions inherent in IPM Version 3.0 are actually better than those in IPM Version 2.19. The uncertainties in the IPM are exacerbated by the fact that the initial planning year for the regional haze SIPs is 2018, far beyond the historic planning years for other SIPs.

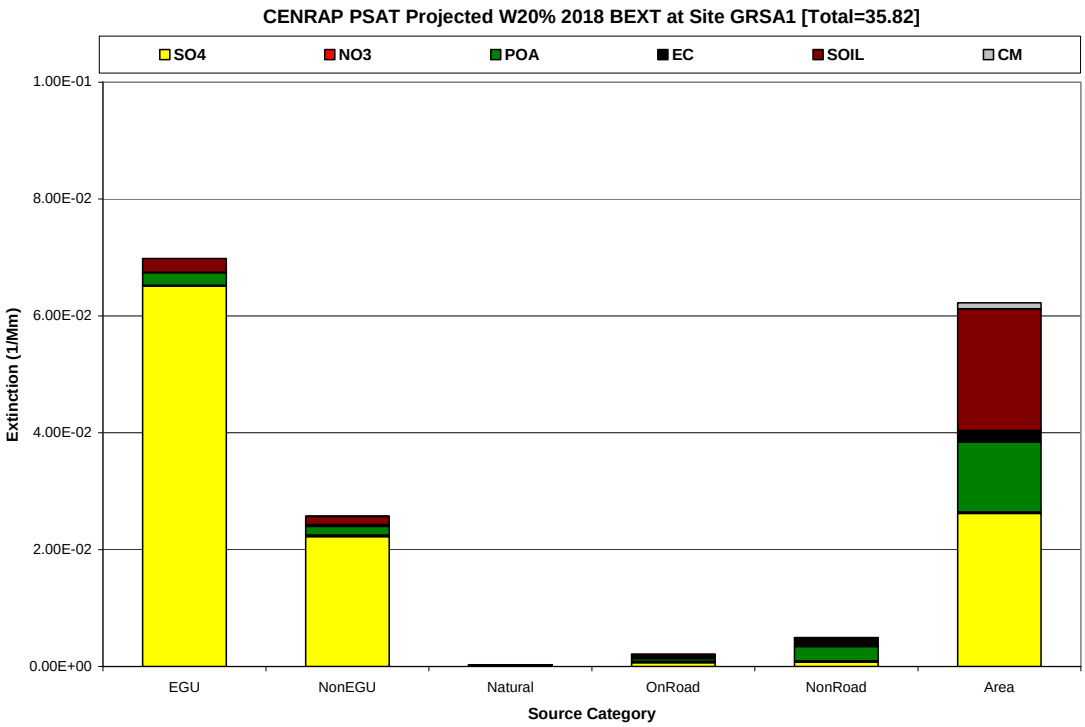
Because of the great complexity of the IPM, the reasons for its predictions on a unit-specific or plant-specific basis are particularly difficult to discern. Some of the uncertainty in the finer scale predictions is likely due to the nature of cap and trade programs such as CAIR, a program upon which the IPM runs are based and the implementation of which is highly dependent on decisions made at the utility company level.

Uncertainties are also inherent in the technical analyses presented in this paper. The approaches used for comparing the results of the IPM versions, particularly the calculation and comparison of Q/Ds and use of residence time plots, contain large uncertainties. Meteorological uncertainties can be large for the residence time plots, since they are based on back trajectories that are highly uncertain due to normal fluctuations and turbulence in wind flow. Overall, these methods cannot be viewed as a substitute for photochemical modeling, the use of which would be the best means of comparing the effect of using one IPM version over another. Photochemical modeling does contain uncertainties, but it is scientifically much more rigorous than the methods used in the current analysis.

Table 14. Q/D Analysis for White Mountain Based on Residence Time Plot

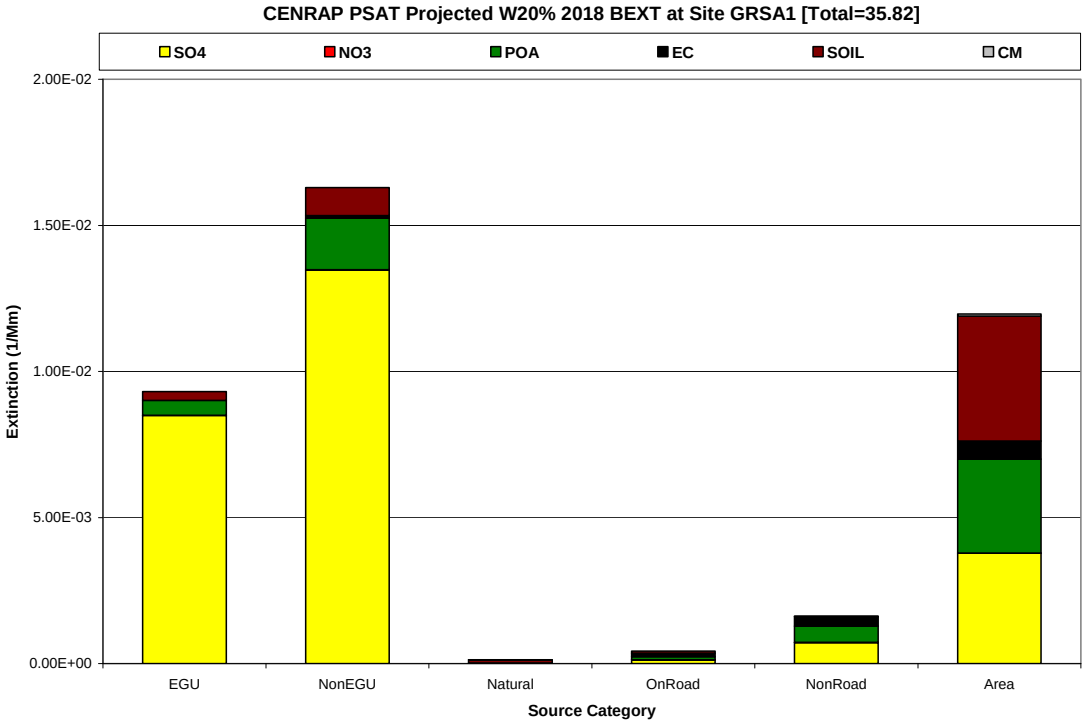
Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone			
Monticello	Titus			
Martin Lake	Harrison	34	36	
Welsh	Titus			
Pirkey	Harrison	19	13	
Southeast Texas				
W.A. Parish	Fort Bend	15	43	
AES Deepwater	Harris	0	4	
Mid Coastal Texas				
Coleto Creek	Goliad	17	14	
BP Chemicals Green Lake	Calhoun	0	0	
Formosa Plastics	Calhoun	0	2	
Valley				
La Palma	Cameron	0	1	
Central Texas				
Sandow	Milam	16	17	
Oak Grove	Robertson	0	17	Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan	4	4	
Twin Oaks	Robertson			
NRG Limestone	Limestone	19	12	
Gibbons Creek	Grimes	3	2	
City of Bryan	Brazos	0	0	
Dansby Power Plant	Brazos	0	0	
Fayette Power Plant	Fayette	25	5	
South Central Texas				
Deely/Sommers/Spruce	Bexar	34	30	
San Miguel	Atascosa	8	9	
West Central Texas				
San Angelo Power Station	Tom Green	2	0	
North Central Texas				
Oklaunion	Wilbarger	12	11	
Panhandle				
Celanese Chemical Manufacturing	Gray			
Tolk Station	Lamb	74	78	
Harrington Station	Potter	54	55	
Borger Plant and Engineered Carbons Cogen	Hutchinson			
Overall Average		**15**	**16**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.



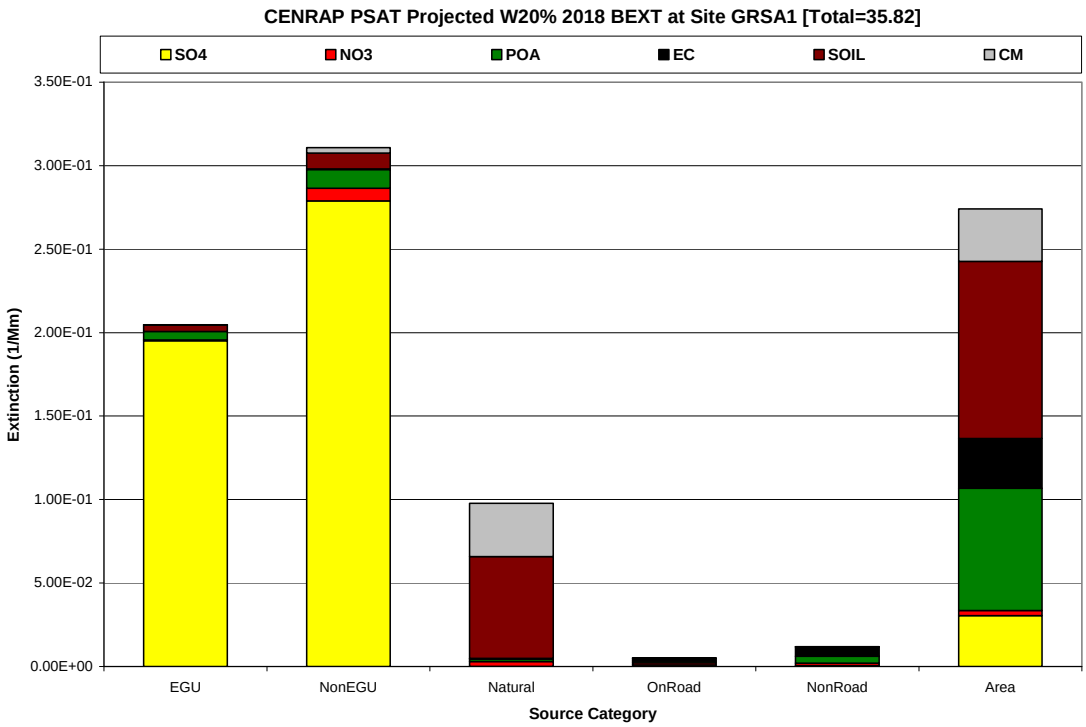
Source: Environ, 2007

Figure 41. Projected Contributions to Light Extinction at Great Sand Dunes from East Texas Region – 20 Percent Worst Visibility Days – 2018



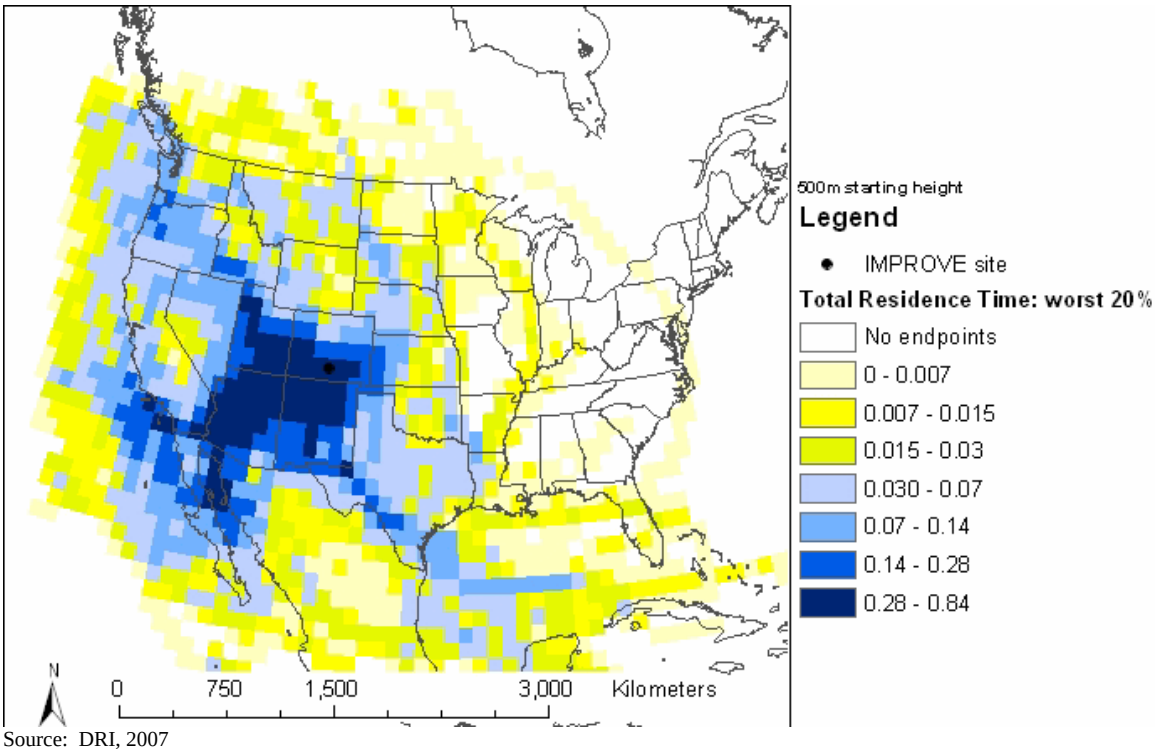
Source: Environ, 2007

Figure 42. Projected Contributions to Light Extinction at Great Sand Dunes from Texas Gulf Coast Region – 20 Percent Worst Visibility Days – 2018



Source: Environ, 2007

Figure 43. Projected Contributions to Light Extinction at Great Sand Dunes from West Texas Region – 20 Percent Worst Visibility Days – 2018



Source: DRI, 2007

Figure 44. Residence Time Plot for Great Sand Dunes for 20 Percent Worst Visibility Days, Period of Record: 2000-2002

Table 15. Q/D Analysis for Great Sand Dunes Based on Residence Time Plot

Plant	County	Q/D IPM 2.19 (tons/year-kilometer)	Q/D IPM 3.0 (tons/year-kilometer)	Comments
Northeast Texas				
Big Brown	Freestone			
Monticello	Titus			
Martin Lake	Harrison			
Welsh	Titus			
Pirkey	Harrison			
Southeast Texas				
W.A. Parish	Fort Bend			
AES Deepwater	Harris			
Mid Coastal Texas				
Coleto Creek	Goliad			
BP Chemicals Green Lake	Calhoun			
Formosa Plastics	Calhoun			
Valley				
La Palma	Cameron			
Central Texas				
Sandow	Milam			
Oak Grove	Robertson			Oak Grove was in IPM 3.0, but not in IPM 2.19
Sandy Creek	McLennan			
Twin Oaks	Robertson			
NRG Limestone	Limestone			
Gibbons Creek	Grimes			
City of Bryan	Brazos			
Dansby Power Plant	Brazos			
Fayette Power Plant	Fayette			
South Central Texas				
Deely/Sommers/Spruce	Bexar	24	22	
San Miguel	Atascosa	5	6	
West Central Texas				
San Angelo Power Station	Tom Green			
North Central Texas				
Oklaunion	Wilbarger			
Panhandle				
Celanese Chemical Manufacturing	Gray	2	1	
Tolk Station	Lamb			
Harrington Station	Potter	52	53	
Borger Plant and Engineered Carbons Cogen	Hutchinson	0	0	
Overall Average		**17**	**17**	

Note: Values of Q/D are shown only for those SO_2-emitting plants in the geographical groupings indicated by the residence time plot for this Class I area. Values of zero indicate that the emission rates were sufficiently low or distance to the Class I area so large that Q/D rounded down to zero.

Conclusions and Options

In spite of the uncertainties in the analyses the TCEQ conducted to compare IPM Version 2.19 and IPM Version 3.0, the results provide an indication that photochemical modeling for 2018 based on EGU emissions projected by IPM Version 2.19 may be a viable option for regional haze planning in Texas. The primary evidence for this conclusion is the fact that overall EGU emissions of SO_2 projected by the two versions are very similar, as are the average Q/Ds for the source groupings for all of the studied Class I areas.

The TCEQ considered awaiting CENRAP's photochemical modeling based on the IPM Version 3.0. Implementing this option would provide technical information based on more up-to-date assumptions in the IPM. However, CENRAP does not currently plan to revise the photochemical modeling based on the newer IPM version. As noted earlier, the TCEQ cannot be confident that IPM Version 3.0 would project EGU emissions that are actually more representative than those from IPM Version 2.19.

References

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