



MEMORANDUM

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TO: Pat Cummins STI Ref. No. 900420

FROM: Patrick Ryan, Ph.D.

SUBJECT: IAS Sulfate Predictions

The purpose of this memo is to report on the changes in sulfate (SO₄) concentrations predicted by the Integrated Assessment System (IAS) associated with the various Annex milestones for calendar year 2018. The five Annex milestones being considered are as follows:

1. The EPA command and control scenario forces certain major SO₂ sources in the west to implement controls resulting in an allowable emission rate for major stationary sources in the west of 509,000 tons per year (t/y). Major stationary sources are defined as those sources emitting at least 100 t/y of sulfur dioxide.
2. The other four (4) Annex milestones are so-called least-cost SO₂ emission caps. These milestones apply a least-cost market-based approach to identify major stationary sources most likely to implement controls so that major stationary sources in the region as a whole comply with the cap. These four (4) milestones are as follows:
 - EPA's milestone scenario, which is an emission cap of 507,000 t/y
 - MTF's milestone scenario, which is an emission cap of 529,000 t/y
 - Environmental milestone scenario with an emission cap of 448,000 t/y
 - Minority milestone scenario with an emission cap of 588,000 t/y

Tables 1 and 2 show the predicted change in sulfate concentration in units of nanograms per cubic meter (ng/m³) and as a percentage of the baseline forecast. The sulfate concentration changes listed are those expected due to adopting each of the five Annex milestone scenarios identified above relative to the baseline forecast of sulfate concentrations at the 16 Class I areas of interest in calendar year 2018. The tables list the expected annual average change as well as

the sulfate concentration change expected for the 20 percent worst and 20 percent best visibility days in the calendar year. For each of the five milestones, the maximum, minimum, and average sulfate change expected for the 16 Class I areas of interest is reported. The maximum and minimum values correspond to the highest and lowest sulfate change expected. The average is an arithmetic average of the sulfate change predicted over the 16 Class I areas. The concentration changes as reported below were determined from the IAS predictions of sulfate as reported in **Tables A-1 through A-3, Appendix A**. Table A-1 lists annual average IAS predictions of sulfate at the 16 Class I areas. Tables A-2 and A-3 list IAS predictions of sulfate concentration for the 20 percent worst and 20 percent best visibility days in the calendar year. IAS predictions of sulfate are provided for calendar year 1990, 2000, 2018 and for the five sulfur dioxide milestones under consideration.

Table 1. Changes in Sulfate Concentration (ng/m^3) associated with various Annex milestones

STATISTIC	EPA C&C	EPA CAP & TRADE	MTF CAP & TRADE	ENVIRONMENTAL CAP & TRADE	MINORITY CAP & TRADE
Annual Avg	53	49	39	76	13
Min	27	26	21	41	7
Max	76	68	55	102	23
20% Worst Avg	101	93	74	143	21
Min	56	59	39	91	8
Max	171	153	124	227	35
20% Best Avg	23	21	18	33	7
Min	7	7	6	12	3
Max	45	37	35	56	11

Table 2. Percent Changes in Sulfate Concentration associated with various Annex milestones

STATISTIC	EPA C&C	EPA CAP & TRADE	MTF CAP & TRADE	ENVIRONMENTAL CAP & TRADE	MINORITY CAP & TRADE
Annual Avg	8%	7%	6%	11%	2%
Min	5%	4%	3%	7%	1%
Max	11%	9%	8%	14%	4%
20% Worst Avg	9%	8%	6%	12%	2%
Min	5%	5%	4%	8%	1%
Max	11%	10%	8%	18%	4%
20% Best Avg	8%	7%	6%	11%	2%
Min	3%	3%	3%	4%	1%
Max	16%	13%	13%	19%	5%

Appendix A

IAS Predictions of Sulfate Concentrations (ng/m³)

Table A-1. Annual Average Sulfate Concentration (ng/m³) associated with Calendar Years 1990, 2000, 2018 and the five Annex milestones

CLASS I AREA	1990	2000	BASELINE 2018	EPA COMMAND & CONTROL	EPA CAP & TRADE	MTF CAP & TRADE	ENVIRONMENTAL CAP & TRADE	MINORITY CAP & TRADE
Arches Nat'l	787	680	678	605	616	623	586	664
Black Canyon	685	584	581	549	551	556	534	572
Bryce Canyon	866	720	713	654	654	666	611	695
Canyonlands	780	672	672	600	612	619	582	659
Capital Reef	672	592	590	545	551	556	530	580
Flat Tops	728	614	616	560	564	574	537	593
Grand Canyon	838	722	711	673	677	685	656	702
Maroon Bells	781	622	629	577	575	587	545	610
Mesa Verde	872	757	758	688	695	708	662	746
Mount Baldy	902	832	827	786	790	800	769	817
Petrified Forest	901	775	771	713	718	729	690	761
San Pedro Parks	869	778	779	703	711	724	677	766
Sycamore Canyon	801	735	731	690	695	708	670	724
Weminuche	740	646	651	593	598	608	565	638
West Elk	812	648	654	600	598	611	566	635
Zion	697	607	598	570	572	577	557	590

Table A-2. Sulfate Concentration (ng/m³) predicted for the 20 percent worst visibility days associated with Calendar Years 1990, 2000, 2018 and the five Annex milestones

CLASS I AREA	1990	2000	BASELINE 2018	EPA COMMAND & CONTROL	EPA CAP & TRADE	MTF CAP & TRADE	ENVIRONMENTAL CAP & TRADE	MINORITY CAP & TRADE
Arches Nat'l	1525	1268	1259	1142	1159	1175	1102	1238
Black Canyon	1441	1168	1159	1075	1083	1098	1044	1142
Bryce Canyon	973	775	770	697	690	706	634	741
Canyonlands	1519	1260	1253	1134	1153	1169	1096	1235
Capital Reef	1292	1111	1102	997	1012	1027	966	1084
Flat Tops	1242	1028	1023	923	927	946	879	988
Grand Canyon	1711	1491	1452	1368	1374	1393	1328	1436
Maroon Bells	850	629	647	591	580	594	546	620
Mesa Verde	1883	1628	1627	1456	1474	1503	1401	1603
Mount Baldy	1575	1468	1458	1369	1379	1404	1332	1442
Petrified Forest	1251	1113	1107	1003	1011	1028	970	1091
San Pedro Parks	1832	1618	1613	1452	1467	1498	1398	1589
Sycamore Canyon	1203	1116	1111	1036	1046	1072	1002	1102
Weminuche	1596	1390	1396	1249	1264	1291	1192	1369
West Elk	908	670	688	627	617	632	580	660
Zion	1410	1174	1148	1086	1089	1100	1058	1134

Table A-3. Sulfate Concentration (ng/m³) predicted for the 20 percent best visibility days associated with Calendar Years 1990, 2000, 2018 and the five Annex milestones

CLASS I AREA	1990	2000	BASELINE 2018	EPA COMMAND & CONTROL	EPA CAP & TRADE	MTF CAP & TRADE	ENVIRONMENTAL CAP & TRADE	MINORITY CAP & TRADE
Arches Nat'l	303	276	278	233	241	242	226	269
Black Canyon	238	211	214	207	206	208	201	211
Bryce Canyon	480	411	410	379	380	385	355	400
Canyonlands	331	300	303	259	267	269	251	294
Capital Reef	143	235	237	221	222	223	215	232
Flat Tops	268	231	233	211	213	216	203	222
Grand Canyon	319	261	261	251	251	254	245	258
Maroon Bells	447	371	374	339	341	347	322	364
Mesa Verde	287	262	264	240	242	246	230	258
Mount Baldy	374	344	343	333	334	335	329	339
Petrified Forest	578	477	473	442	445	450	429	466
San Pedro Parks	236	212	215	194	196	199	187	210
Sycamore Canyon	419	370	366	348	349	354	338	361
Weminuche	203	186	190	175	176	178	168	185
West Elk	461	380	382	348	349	355	330	372
Zion	259	234	237	230	229	231	225	233