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RE: Comments To The Revised Draft Supplemental Environmental Impact Statement, Pinedale Anticline Oil and Gas Exploration and Development Project, Sublette County, Wyoming

Please find attached our comments to the Revised Draft Supplemental Environmental Impact Statement (RDSEIS) regarding the Pinedale Anticline Oil and Gas Project. BP is a leaseholder within the Anticline and currently operates within the project area. BP is a leading producer of natural gas in North America and a global producer and manufacturer of oil, natural gas, petroleum products and petrochemicals. The company is also internationally recognized as a leader in environmentally responsible operations and corporate transparency.

We have conducted a review of the RDSEIS and attempted to provide a commentary document that highlights our areas of concern. BP previously provided detailed comments on the December 2006 draft of the Pinedale Anticline Oil and Gas Exploration Project – Supplemental EIS (dated April 6, 2007).

These earlier comments addressed accuracy of the emission inventory development and accuracy of the air quality modeling and interpretation of projected impacts. In the revised December 2007 document, BLM has not provided any clear information on how or if our concerns were addressed. Based on BP's review of the revised document, it appears that the majority of the issues identified and commented on were not addressed. BP recommends that BLM address these technical concerns in order to present an accurate document for public review and ultimately for approval of the development plan.

Because it appears that the previous BP comments were not addressed, BP is resubmitting these comments today and believes that the technical issues previously raised remain important and, without proper resolution, will result in the application of inappropriate mitigation decisions by BLM.

In addition to the previous comments, BP is also submitting comments on the following aspects of the Supplemental Draft.

1) Ozone modeling
2) New alternatives
3) Additional information on the accuracy of the CALPUFF nitrate and ammonia chemistry

Thank you for considering our comments to the RDSEIS.

Sincerely,

cc: Ron Kainer - BP Houston
Tom Robinson - BP Jonah OC
Don Brooks - BP Jonah OC
Gary Austin-BP Denver

**BP Comments on the Air Quality Impact Analysis Technical Support Document
For the Revised Supplemental Environmental Impact Statement
For the Pinedale Anticline Oil and Gas Exploration Project**

P-5-1 AQ-1 AQ-2

BP previously provided extensive detailed comments on the air quality sections of the initial draft of the Pinedale Anticline Oil and Gas Exploration Project – Supplemental EIS (dated December 2006). Broadly, these comments addressed accuracy of the emission inventory development and accuracy of the air quality modeling and interpretation of projected impacts. In the revised document, BLM has not provided any clear information on how or if these concerns were addressed. Based on BP's review of the revised document, it appears that the majority of the issues identified and commented on were not addressed. BP believes that BLM must address these technical concerns in order to present an accurate document for public review and ultimately for approval of the development plan. It is recommended that BLM provide a detailed summary of comments as well as supportable technical documentation for the necessary resolution of the issues raised.

Because it appears that our previous comments were not addressed, BP is resubmitting our comments on the SDEIS submitted on April 6, 2007, (Attachment 1) and believes that the technical issues previously raised remain important. These comments, without proper resolution, will result in the application of inappropriate mitigation decisions by BLM.

In addition to the previous comments, BP is also submitting additional comments on the following aspects of the Revised Supplemental Draft.

1) Ozone modeling
2) New alternatives
3) Additional information on the accuracy of the CALPUFF nitrate and ammonia chemistry

P-5-2

Ozone Modeling

The use of the CAMx modeling in the supplemental draft for ozone modeling is a vast improvement over the CALGRID analysis in the original draft. The most important aspect of the new CAMx analysis is that a 4 kilometer grid resolution was used compared to a 36 kilometer grid in the CALGRID modeling. It is unfortunate that when the CAMx modeling was performed

P-5-2 AQ-3

that the secondary particulate switch was not turned on so that the model computed potential visibility and deposition impacts in sensitive areas. Because CAMx has a more complete and accurate description of the atmospheric photochemical process, the use of CAMx would have addressed the model accuracy issues that BP has raised regarding the application of CALPUFF for secondary particulates. If additional modeling is conducted, we recommend that BLM use CAMx rather than CALPUFF for secondary particulate analysis.

AQ-4 P-5-3

While the application of CAMx is an improvement over CALGRID, there are a number of technical issues associated with the application of the CAMx model for estimating ozone formation, as a result of the proposed development, that BLM needs to address. These issues are outlined in the following subsections.

Accuracy of Meteorological Input to the Model

The CALMET meteorological model was used to provide meteorological input to the CAMx model. CALMET used MM5 meteorological modeling for 2002 and other local meteorological data. These are the same data that BLM used in the Moxa Arch EIS analysis. BP has previously reviewed the accuracy of these meteorological modeling results compared to additional meteorological monitoring data collected in Southwest Wyoming. The results of that analysis are presented in the following.

AQ-5 AQ-6 P-5-4

It is important to review how BLM developed the CALMET wind fields. The starting point of the wind fields was MM5 modeling results for 2002 and was conducted on a 12 kilometer grid system. The MM5 modeling was not part of the BLM analysis and was provided by other agencies to BLM. BLM, however, has not provided any documentation on how the MM5 modeling was conducted. The use of a 12 kilometer grid is very important in the assessment of the accuracy of the meteorological modeling because it means that terrain in the region is averaged over a 12 kilometer grid square. Thus, any terrain in the region is averaged or smoothed over a relatively large region. CALMET then interpolated the MM5 results to a 4 kilometer grid square.

P-5-5

In addition to the MM5 meteorological modeling, a limited number of surface meteorological stations and even fewer upper air stations were used to supplement the MM5 modeling analysis. It is important to note that the size of the modeling domain was 508 kilometers by 608 kilometers and the use of only limited surface meteorological stations over such a large domain, AQ-7 P-5-5 places dominance on the 12 kilometer MM5 modeling without any justification. BLM does not provide any documentation on which surface and upper air stations were used in the analysis. The BLM document does not provide any evaluation of the accuracy of developed wind fields compared to independent data.

Because of the uncertainty of the accuracy of the meteorological wind fields, BP conducted a limited evaluation of the accuracy of the CALMET wind fields. BP tested the accuracy of the MM5 simulations by extracting wind speed and direction predictions from CALMET for the Jonah meteorological tower. The CALMET extraction was done for 2002 using the MAKEMET program which is part of the CALMET/CALPUFF modeling system.

Figure 1 presents a map of the region with measured wind roses from selected meteorological towers in the region as well as a wind rose from CALMET for the Jonah tower.

The meteorological data to the CALPUFF model was initialized with MM5 modeling on a 12 km grid from less than 500 observation sites covering the entire US. This modeling is done primarily for meso-scale wind transport forecasting.

CALMET used 13 NWS surface sites contained in the modeling domain and 100 meter spaced surface elevation data to model the surface flows on a 4 kilometer grid. CALMET makes several smoothing passes to arrive at a divergence free, fluid conservative and consistent wind field of 10 vertical layers from surface to 4500 meters. The first 8 layers are at or below the 1000 meter base of the MM5 model, the region of interest for pollutant transport for oil and gas emissions.

CALMET uses weighting of inverse distance from grid point to surface station to determine the choice of wind speed and direction assigned to the grid cell. Figure 1 shows that for most of the direct path from Moxa Arch to the Bridger Class I Area, the Lander station is the prime influence. The topography shows that Lander is beyond the east down slope of the Bridger ridge. The representative Jonah point is before the west upslope barrier of the Bridger ridge. One important point is that the Jonah meteorological tower is located in a high desert plain and there are no terrain issues within 10 km that would locally affect winds. The Jonah observations are similar to others at Boulder, Pinedale and Daniel sites in the same valley plain.

AQ-8 P-5-6 The EIS modeling for Moxa Arch scenarios should incorporate additional station observations from sites in the likely direct trajectory paths from Moxa Arch to the Bridger Class I Area. Data

AQ-8 P-5-6 is available from WDEQ. It is likely several other sites can be found between Rock Springs and Jonah.

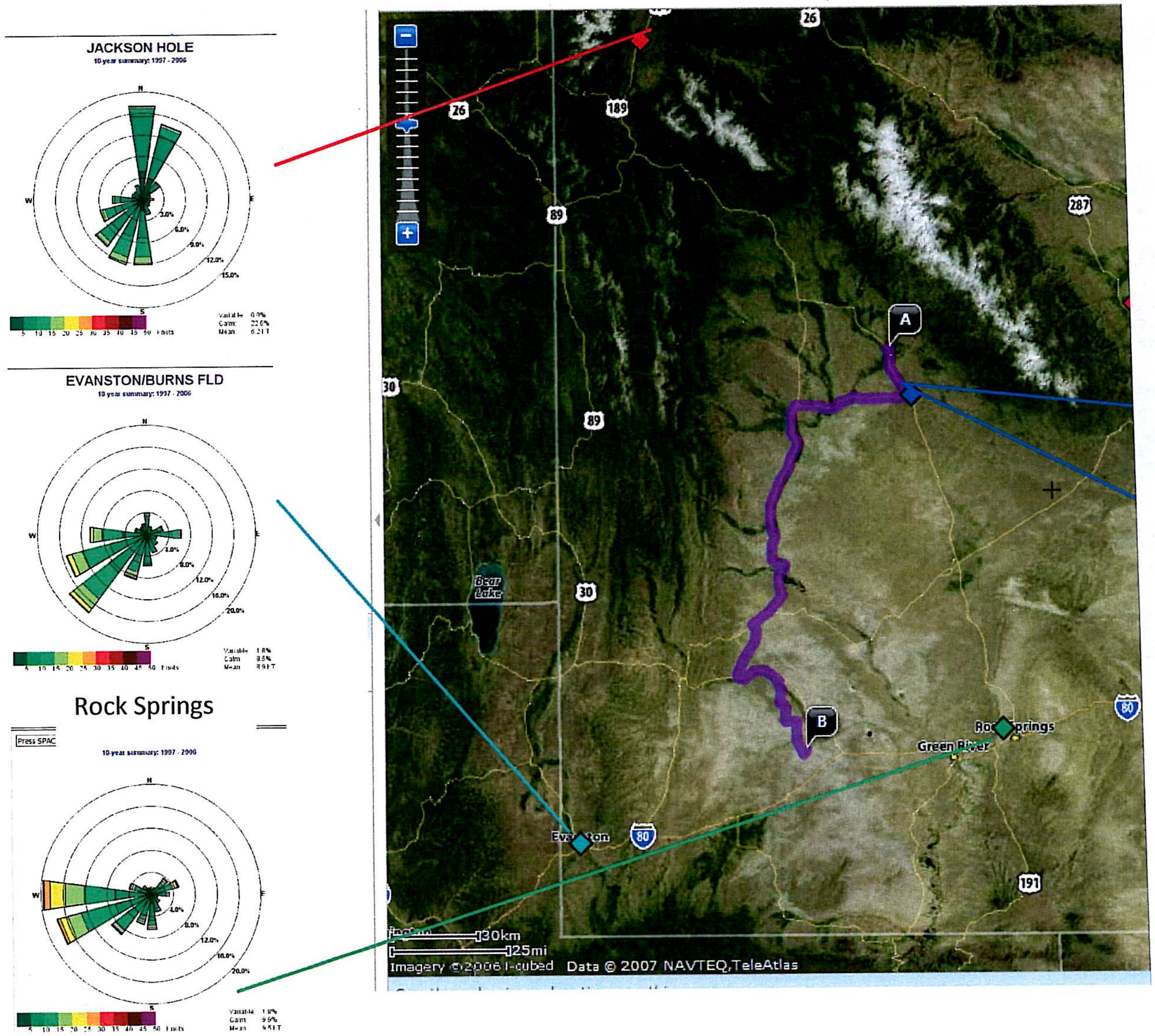


Figure 1. Terrain, Measured and CALMET Modeled Wind Ros

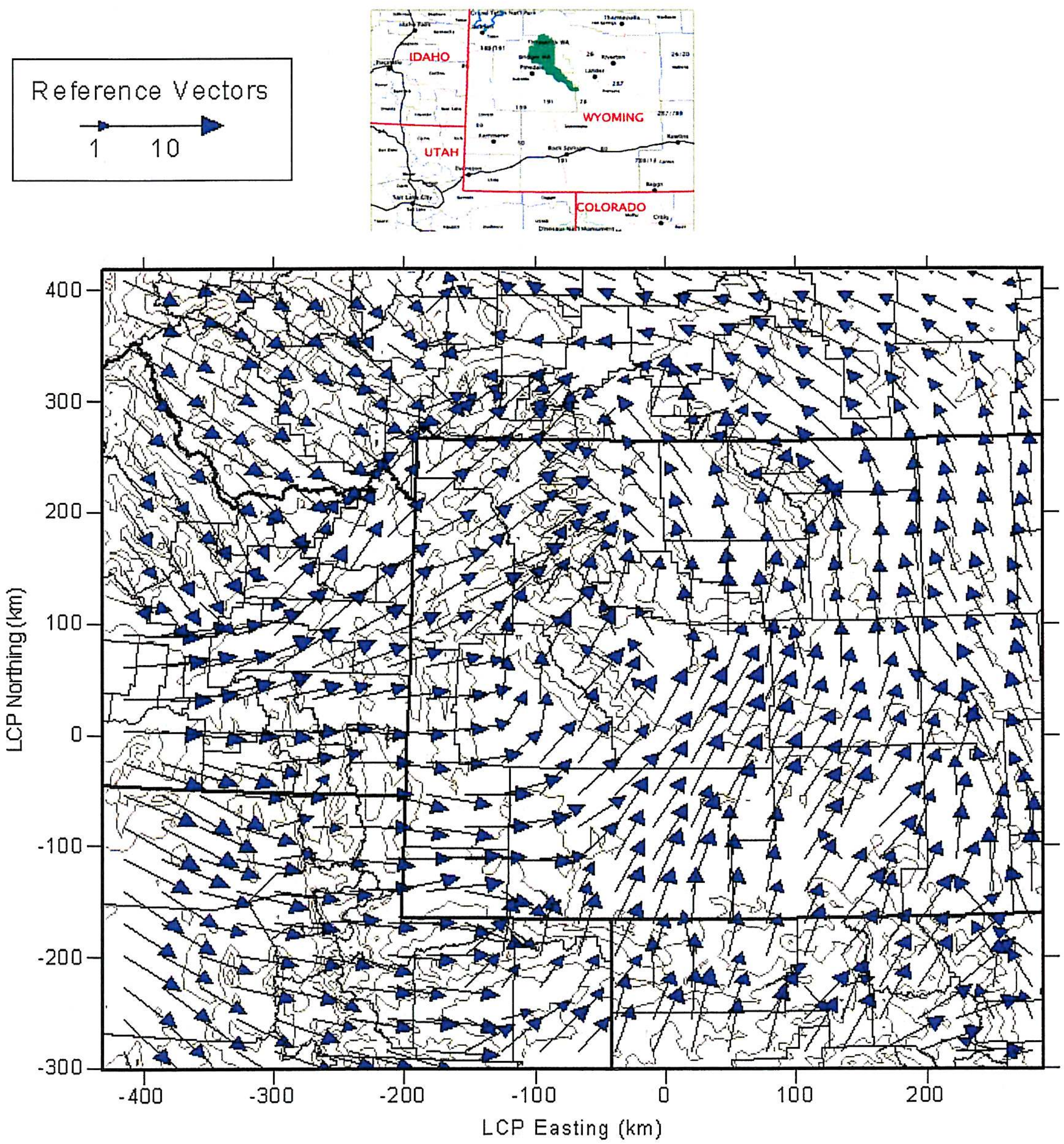
Note: Point B is the Central Point for Moxa Arch Development. Point A is l

Figure 1. Terrain, Measured and CALMET Modeled Wind Roses in Southwest Wyoming

Note: Point B is the Central Point for Moxa Arch Development. Point A is Boulder, WY which is North of Jonah

AQ-9 P-5-7 To support the need for more meteorological data for the large modeling domain, the following wind fields were excerpted from http://deq.state.wy.us/aqd/Modeling%20Studies.asp. (Appendix B - CALMET Wind Vector Plots for Top 10 NO2 Concentration Days)

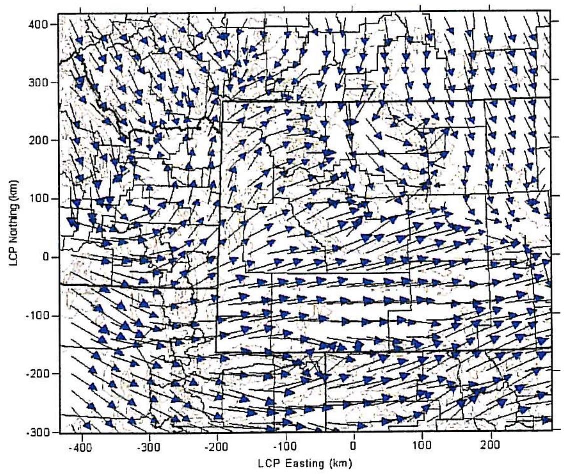
The first plot shows possible direct transport from Moxa Arch to Bridger.



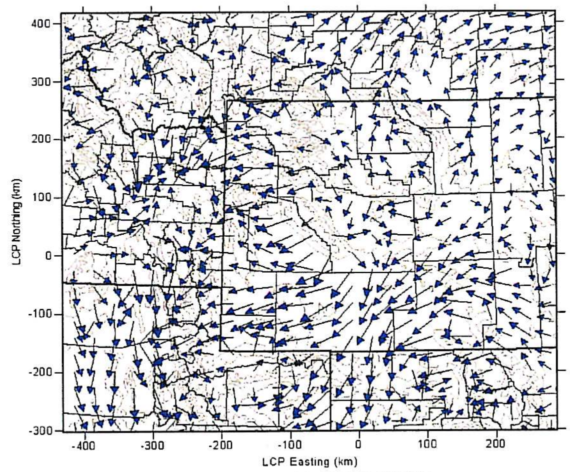
Surface Winds (m/s) at 12 MST, 20010412

AQ-10 P-5-8 The next several plots present vector flows that appear to be unrealistic of flow in the region. Each plot indicates confused flows in the Jonah plain and in the northeast quadrant that need to

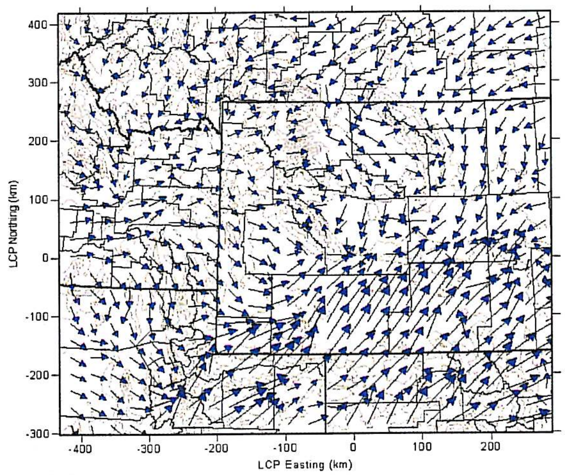
AQ-10 P-5-8 be resolved by using additional meteorological stations in the meteorological modeling. It is likely that an additional surface station is needed to resolve flows in the northeast quadrant.



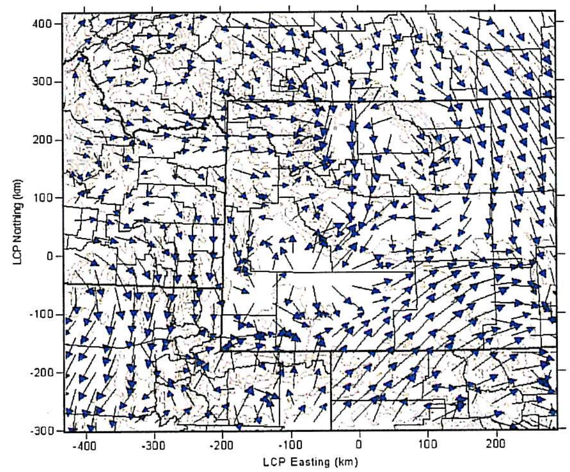
Surface Winds (m/s) at 12 MST, 20010906



Surface Winds (m/s) at 24 MST, 20021031



Surface Winds (m/s) at 12 MST, 20020128



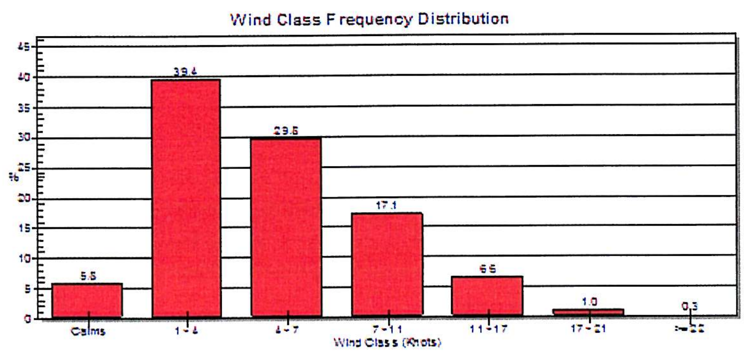
Surface Winds (m/s) at 12 MST, 20010929

Modeled Wind Speed

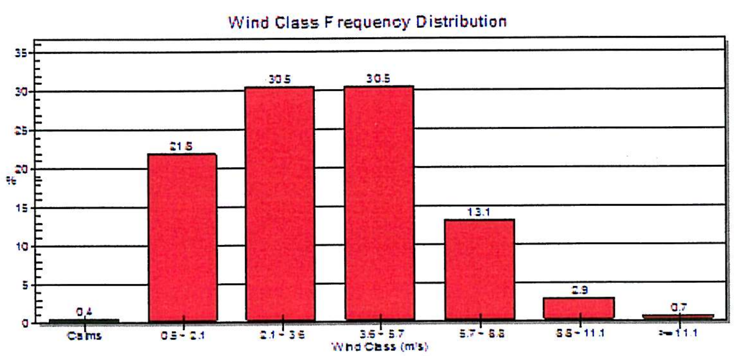
AQ-11 P-5-9

The following figures present CALMET modeled wind speed and observed wind speed at the Jonah tower. These figures indicate that the CALMET predicted wind speed is considerably lower that the observed wind speed. This finding is in addition to the predicted wind direction is not correct. The fact that the wind speed is under predicted is important because it affects the dispersion of the plume and also the rate of chemical transformation.

CALMET at Jonah grid cell 2001 – 2003



Jonah Measured 2005



AQ-12 P-5-10

In conclusion, there appears to be very large uncertainty in the wind fields used by BLM in the CALMET/CAMx modeling that needs to be resolved before additional modeling is conducted. In developing a more complete evaluation of the meteorological input to the CAMx model it is recommended that as a starting point, BLM should generate wind field plots for days with predicted elevated ozone concentrations.

Ozone Modeling Emission Inventory Issues

AQ-13 P-5-11 There are several issues regarding the emission data that were input to the CAMx model. First, BLM needs to provide speciation information on VOC emissions and the profiles need to be compared to actual speciation data for the sources of concern. Second, information is needed regarding the emissions input to the model. It is recommended that BLM provide a matrix of emissions by pollutant for source types included in the modeling. This should be done for the 4, 12 and 36 kilometer grids, especially for oil and gas as well as biogenics emissions.

AQ-14 P-5-12 There is insufficient detail in the ozone modeling analysis to evaluate the emission inventory used for the future year development.

Model Evaluation of CAMx Model for Ozone

P-5-13 Review of the model performance statistics indicate that the CAMx model is replicating observed concentrations within EPA specified limits. However, given the concerns that BP identified regarding the accuracy of the meteorological input to the model and the uncertainty in the WRAP VOC oil and gas emissions, there is concern that the agreement between the model results and the monitoring data may be a result of compensating errors. If the agreement between modeling results and monitoring data is fortuitous, there is concern that the model may not estimate future impacts correctly. AQ-15 It is recommended that additional analyses be presented in the document that clarifies model performance.

AQ-16 P-5-14 It is also recommended that BLM consider the predicted spike in ozone near Yellowstone National Park as a modeling artifact. There is no information to suggest that the elevated concentration actually occurred.

Other Comments Regarding Ozone Modeling

AQ-17 P-5-15 BLM needs to provide source apportionment modeling results for days when predicted ozone is elevated. The following source groups should be considered:

1) Proposed new sources;
2) Current baseline conditions within the 4 kilometer grid;
3) Ozone transported into the region (e.g. Denver, Salt Lake City and other urban emissions);

AQ-17 P-5-15

4) Biogenic emissions; and
5) Background ozone transported in from the 36 kilometer grid

By developing source apportionment information for critical days, it is possible to understand the actual predicted impact of the proposed development.

Ozone Impacts for Future Years

AQ-18 P-5-16

BLM should not consider the maximum 4/12 kilometer absolute maximum impacts in evaluation of ozone impacts (83.8 for Case 1 and Case 2). The predicted impacts occurred in northeastern Colorado and there is no analysis of source culpability. It is very unlikely that the projected impacts are due to the proposed development since the total impacts from Case 1 and Case 2 are identical. Presentation of wind fields for selected days will also help identify source attribution.

New Alternatives

AQ-19 P-5-17

The BLM supplemental draft presents mitigation options that were not identified in the original document. The documentation for the development of these options is very incomplete and the BLM document must present technical and economic evaluations of such mitigation options. The first mitigation option is Alternative C (Phase 1) which requires that emissions be capped at PAP 2005 levels. The second mitigation option assumes that in addition to Alternative C (Phase 1), drilling emissions be further reduced by 80 percent over 2005 levels.

AQ-20 P-5-18

There are many problems associated with the new mitigation options. First, from a visibility perspective, other than flawed CALPUFF modeling, there is no demonstrated need for the mitigation options. It is important to note that there has been no change in monitored visibility in the Bridger Class I Area[1]. If BLM were to implement this option, it would essentially establish an emission cap where offsets would be required for new development. Thus for new development to occur, emission offsets would be required. Clearly, the regulatory authority of such a program lies with WDEQ and not BLM. For WDEQ to establish such a program would require them to follow appropriate regulatory promulgation which is beyond the scope of an EIS.

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[1] BP has previously submitted detailed comments on trends in visibility as part of comments on the Pinedale Supplemental EIS which are included as an attachment to this document.

In addition, such a requirement would require excessive emission controls well beyond current WDEQ BACT levels and perhaps beyond currently available technology with no technical justification for such action.

AQ-21 P-5-19 The second mitigation option assumes that rigs are mitigated by 80 percent for Alternative C (Phase 1), a case that already assumes excessive controls. The assumption associated with this additional mitigation option is that control technology for emissions on drilling rigs **will not** improve over time. Given the proposed changes in EPA diesel emissions standards for off road engines and the Wyoming minor source BACT (a technology forcing regulation), this assumption is very unreasonable. BP firmly believes that emissions from diesel engines used on drilling rigs will be much lower than was assumed in the modeling analysis. Additionally, in the WRAP Phase II Oil and Gas Inventory, it was reported that rig engines are subject to a current technology 5-10 year replacement cycle. This phased upgrade to the rig engine portfolio should be incorporated into the analysis.

Additional Information on the Accuracy of the CALPUFF Nitrate and Ammonia Chemistry

AQ-22 P-5-20 The American Petroleum Institute (API) has recently conducted an evaluation of the EPA CALPUFF model and based on that review it was concluded that there were errors in formulation of the chemistry modules of the model. A draft copy of the API report is attached to this document. The API study includes both corrections to errors in the existing gas-phase chemistry module as well as incorporation of new science modules for inorganic and organic aerosols and aqueous-phase chemistry.

AQ-23 P-5-21 The changes to the chemistry algorithms in the CALPUFF model were revised to be more consistent with the formulation of CB4 chemical mechanisms in CAMx and CMAQ. Figure 2 presents a comparison of NO3 predictions from the new and previous algorithms in CALPUFF. As indicated in this figure, when the model is run using current state of the art chemical formulations (consistent with CAMx and CMAQ), substantially lower NO3 concentrations are predicted.

Figure 1. Comparison of CALPUFF Chemistry Modules

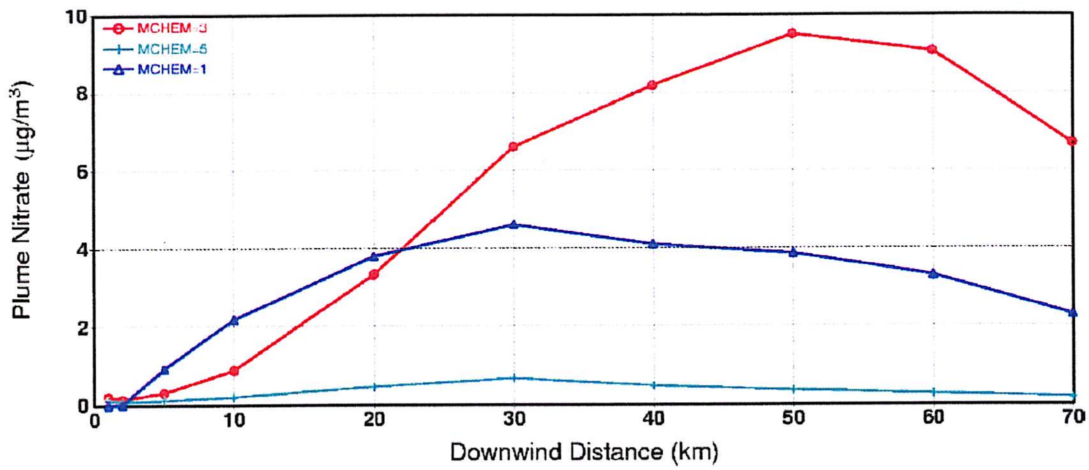

Figure 3-15. Plume centerline HNO_3 and particulate nitrate concentrations as a function of downwind distance (relative humidity set to 95%). MCHEM=1 refers to the MESOPUFF II option, while MCHEM=3 refers to the original RIVAD treatment, and MCHEM=5 refers to the new RIVAD treatment (ISORROPIA).

AQ-24 P-5-22 API also found that through conducting low temperature sensitivity studies another important shortcoming of CALPUFF was identified, its lack of treatment of ammonia limitation for multiple or overlapping puffs. This finding leads to substantial overestimation of particulate nitrate formation at downwind receptors. This shortcoming can be addressed by a post-processing step to recalculate inorganic aerosol equilibrium at receptor locations. In addition, an upper limit for particulate nitrate formation that is based on the amount of ammonia available in the background should be implemented in CALPUFF to prevent the output of particulate ammonium nitrate concentrations that are physically unrealistic (do not conserve mass of ammonia).

AQ-25 P-5-23 In conclusion, the API study further substantiates that visibility impacts predicted by CALPUFF overstate likely impacts from proposed development and do not support the excessive mitigation measures suggested in the BLM supplemental draft.

Attachment 1

Previous BP comments on Air Quality Impact Analysis Technical Support Document for the Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration Project

Attachment 2

API Draft Report
CALPUFF CHEMISTRY UPGRADE
Prepared by

Prakash Karamchandani,
Shu-Yun Chen and Christian Seigneur
Atmospheric & Environmental Research, Inc.

Attachment 1

Previous BP comments on Air Quality Impact Analysis Technical Support Document for the Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration Project

Air Quality Comments on the Pinedale Anticline Supplemental Draft EIS

Alternative C Phase I and II

As BLM correctly notes in their discussion of "Regulatory Authority" in Volume 1, Chapter 4, Section 4.9 Air Quality, Subsection 4.9.3, BLM's responsibility and legal authority in regards to air quality is limited. BLM's extensive air quality analysis provides BLM a basis for meeting this responsibility. However, it does not provided BLM a legal basis for regulation air quality.

The air quality "Alternative Impact Mitigation", introduced in Volume 1, Chapter 4, Section 4.9 Air Quality, Subsection 4.9.5, imposes emissions caps and emissions reduction requirements that are the responsibility of the Wyoming DEQ Air Quality Division or EPA under their regulatory authority. These emission caps and emissions reduction requirements are beyond the BLM's regulatory authority. Setting of emissions caps and/or restrictions in EIS actions has been tested in prior legal proceedings. The answer is no. Exhibit A to these comments provides examples of two such prior tests. BP requests BLM remove emissions caps and emissions reductions, expressed or implied, from the Alternative C proposal.

(Even if BLM had authority for such regulation, which it does not, its air quality modeling is not consistent with over 20 years of monitoring data. More discussion follows on this point.)

BLM proposes to impose these emission caps and emissions reduction requirements both through explicit emissions reduction requirements and goals and through their requirement for periodic air quality modeling to demonstrate impact levels meeting the goals articulated. BLM notes that *"The method by which the Operators would determine project visibility impact would be determined by BLM in consultation with WDEQ, EPA, USFS, and NPS."* Presumably the modeling protocol established by BLM in consultation with these same agencies and used in this DSEIS, represents the collective view of the agencies on the most appropriate modeling approach to use in evaluating potential air quality impact from the proposed action and would continue to be viewed by this same group of agencies as the most appropriate protocol and approach. Given the overly conservative approach of this modeling protocol and approach, discussed later in these comments, the only way to meet the performance objectives set forth in this subsection is through imposing the emissions limits and reductions or restricting development.

In addition to BP's contention that BLM lacks authority to regulate air quality by imposing emission caps and emission reductions, BP is very concerned about the approach the BLM has taken in proposing the Alternative C Phase II emissions and modeling demonstration. Our understanding is that BLM took the following approach to establish this emissions scenario:

- Using the model and inventory as configured for analysis of Alternative C Phase I, and then doing iterative modeling of 20% step reductions, to a maximum of 80% reduction of 2005 actual drilling rig emissions – which itself represents a reduction from current and project proponent proposed drilling rig emissions. There appears to have been no consideration of the technical or economic feasibility of actually making the reductions required and modeled.

This approach ignores almost three decades of well established air quality management regulation and practice regarding analysis and implementation of emission control measures and practices through the "Best Available Control Technology (BACT)" process. Instead, BLM has apparently chosen to arbitrarily establish the level of emission control necessary through the use of dubious predicted impacts from an overly conservative modeling exercise. Although we are supportive of lower emissions and actively pursue emission reduction, we believe these efforts need to be grounded in established technology, cost effective emission reductions and regulation and implemented through a properly crafted and established regulatory program (Wyoming DEQ) or voluntary actions rather than a NEPA analysis and action.

BLM continues this development of Alternative C Phase II by discussion that even this 80% reduction in actual 2005 rig emissions will likely not meet the goal of 0 days of modeled visibility degradation greater than 1 deciview and that additional emissions reductions may be required. BLM properly observes that current compression conforms to Best Available Control Technology (BACT) requirements and that future compression would be required to conform to BACT emission requirements and that most of the engines associated with portable well completion and servicing equipment already meet Tier 2 requirements. BLM also recognizes and states that any further reductions from these sources would be limited. As the following table illustrates, the proposed 80% reduction of rig emissions from 2005 actual emissions levels actually represents an emission reduction of about 87% from the project proponents proposed action rig emissions – which already included Tier 2 equivalent emissions from all new rigs.

2005 Drilling Rig NOx tons/year	2008 Drilling Rig NOx tons/year (proponent proposed action)	Alternative C Phase II Drilling Rig NOx tons/year (would occur in 2012)	Required Rig Engine Reduction % (from proponent proposed action - 2008)
2,590	3,965	518	~87%

As this table clearly illustrates, meeting the Alternative C Phase II rig emissions limits is not feasible with current technology (regardless of how much is spent on control cost). Further, BLM did not consider potential offsetting impacts from suggested control mechanisms (natural gas fired lean burn, selective catalytic reduction, and electric drives and the environmental ramifications of these control mechanisms). Also, meeting this alternative may not result in any perceivable improvement in visibility as discussed below.

BLM should modify the document to acknowledge that the Alternative C emission scenario does not represent achievable emission rates using the "best" current technology. BLM also should explicitly acknowledge that operators will not be required to somehow go beyond current technological limits in achieving emissions goals, and that implementation of current technologies will be subject to the BACT process, through the Wyoming DEQ AQD, which includes economic feasibility and offsetting impact analysis.

Comments on Far Field Visibility Modeling

For the following reasons, BP believes that BLM's use of the CALPUFF modeling approach in this project is arbitrary, irrational, and capricious and accordingly is invalid as a matter of law under the US Administrative Procedures Act.

BP further believes that the Pinedale far field CALPUFF visibility modeling has fundamental flaws that must be corrected in order for BLM to present an accurate disclosure of potential impacts for the proposed Pinedale development with respect to estimating the change in visual range in adjacent Class I Areas. The following issues need to be addressed in a more complete manner:

1) Accuracy of the CALPUFF model with respect to the formation of NO_3 fine particulates that can cause light scattering and reduce visual range;

2) The manner in which concentration predictions are converted into visual range; and

3) The interpretation of what constitutes a "just noticeable" change in visibility.

Accuracy of the CALPUFF Model

During the public comment process of the modeling protocol, BP submitted detailed comments that strongly recommended that an emission inventory of actual emissions be developed which would then be used in a modeling analysis where model predicted concentration estimates would be compared to actual monitored concentrations in the Class I Areas and the model predicted impacts scaled against this comparison. This comparison would identify any bias (amount of over or under prediction compared to measurements) in the CALPUFF model in Class I Areas and would "ground truth" the analysis. Although BLM did model 2005 actual and potential emissions, this information was not used to scale the predicted impacts against the ratio to the actual monitoring data and correct for the model bias.

BP and others have previously submitted detailed comments to BLM and other agencies regarding the lack of model evaluation of CALPUFF with respect to secondary aerosols. Previous BP comments (dated January 2006) regarding the Jonah EIS were not adequately addressed by BLM between draft and final in that EIS nor has BLM considered the importance of those comments in the current Pinedale analysis. EPA has recognized the importance of evaluating model accuracy in calculating the effects of secondary aerosols in its draft modeling guidance. In summary, EPA recommends that because of the large uncertainty in accurately predicting secondary aerosols, a model evaluation should be performed and the model should then be used in a relative mode (ratio of model prediction to monitored value) to estimate future case impacts. This draft guidance should be followed by BLM in the Pinedale analysis.

As part of the Pinedale analysis, BLM chose to compile an emission inventory of actual emissions for 2005 oil and gas operations. This inventory was compiled based on operator input, was modeled using CALPUFF and represents current modeled baseline conditions. BLM does not discuss in the Technical Support Document (TSD) why this inventory was developed nor how the modeling impacts should be interpreted.

As the document stands, the 2005 baseline analysis leaves the reader with the false impression that as a result of current activities, visibility in the Bridger Class I Area (as well as other Class I Areas) is experiencing substantial degradation from oil and gas operations based on CALPUFF modeling. Conversely, the monitoring data at the Bridger Class I Area has indicated no change in visibility over the period of record (even though emissions have increased). Figure 1 presents the visibility monitoring results at Bridger over the period of record. (Note: BP calculated the statistical data for 2005 using IMPROVE equations.) This figure indicates that visibility is unchanged over the period of record, a very different impression than left by review of the modeling results. This figure presents the best, mid and worst 20 percent of the data, as expressed in inverse mega meters of degradation.

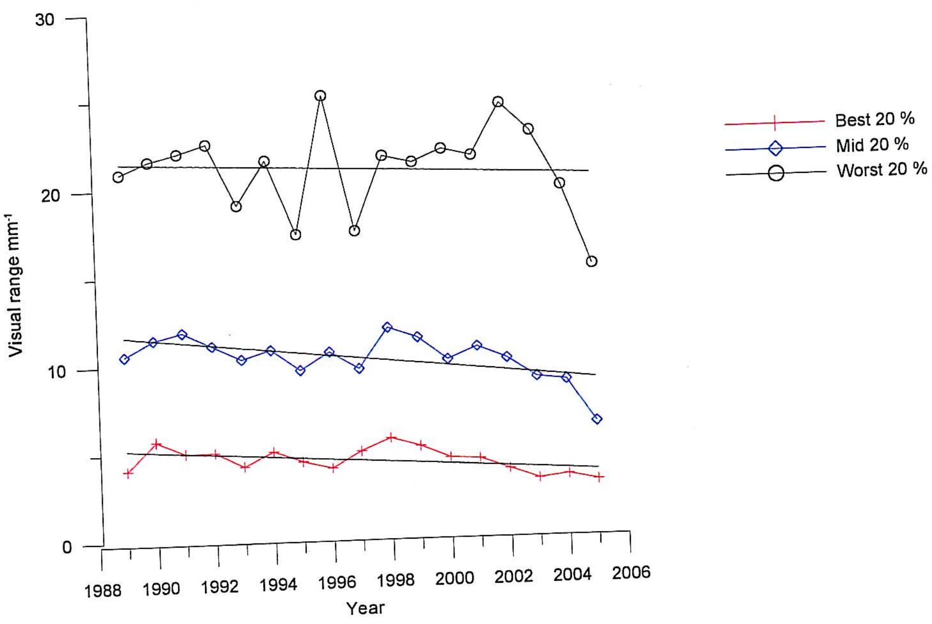

Figure 1. Trends in Visual Range 1988 through 2005

Note: Straight line is least square fit

For the best 20 percent case (i.e., the cleanest days), Figure 1 indicates that there has been a slight trend toward improved visibility. The straight line represents a least square fit through the data and while there is a downward trend, the correlation coefficient is not sufficient to suggest a strong correlation. For the mid 20 percent case, the same trend is apparent as for the best 20 percent data. The trend for the worst 20 percent case appears to be relatively flat. Unfortunately, IMPROVE does not provide error bars on these data in terms of accuracy so it is impossible to identify the significance of these trends. The conclusion is that, at best, there is a slight improvement in visibility and, at worst, there has been no change over the period of record. BLM developed an actual emission inventory which was used in conjunction with 2001, 2002 and 2003 meteorology to estimate current baseline conditions. In order to correct the deficiencies with the Pinedale analysis, BLM must compare the accuracy of the modeling impacts of secondary aerosols to actual monitored secondary aerosols. An analysis using 2005 meteorology data would be the most desirable method of conducting such an analysis. However, in lieu of 2005 meteorological data, the use of maximum impacts over the period 2001 through 2003 could be used. In reality, as indicated in the BLM document, the difference in predicted impacts between years is not substantial and such an analysis using 2001 through 2003 meteorological data would provide an indication of the accuracy of CALPUFF. Because detailed information contained in the draft document is very limited, BP has attempted to conduct analyses that substantiate the need that additional model evaluations are warranted. BP requested modeling input files from TRC and those were used to perform focused analyses that demonstrate the magnitude of the potential over prediction of CALPUFF relative to monitoring data.

The first part of the BP analysis was to examine the relative contribution of NO_3 to visibility. The TRC modeling files provided a CALPOST listing of visibility impacts by day as well as the relative contribution of various PM species including NO_3. Table 1 presents this information from the TRC file using the RHR Average Days sorted in descending visual range. The average predicted NO_3 contribution for days where visibility impairment was in excess of 1 dv was found to be 94 percent. Review of the monitoring data at the Bridger IMPROVE site indicates that for the worst visibility days the NO_3 contribution to the extinction budget was only 3 percent. This comparison provides conclusive evidence that the CALPUFF model, in the mode that BLM chose to run it, does not accurately predict secondary formation of NO_3 particles.

Table 1. Summary of Modeled 2005 Actual Impacts from Oil and Gas

YEAR		HR	RECEPTOR	COORDINATE	(km)	TYPE	DV(Total)	DV(BKG)	DELTA DV	F(RH)	%_SO4	%_NO3	%_OC	%_EC	%_PMC	%_F
2001	316	0	343	25.989	-33.535	D	7.812	1.96	5.853	2.5	0.99	94.95	0	0	0	4.
2001	40	0	343	25.989	-33.535	D	6.259	1.96	4.299	2.3	1.27	94.58	0	0	0	4.
2001	39	0	735	-10.785	7.622	D	5.803	1.96	3.844	2.3	2.86	94.07	0	0	0	3.
2001	332	0	343	25.989	-33.535	D	5.794	1.96	3.834	2.5	2.47	95.24	0	0	0	2.
2001	13	0	636	-5.564	-1.341	D	5.523	1.96	3.563	2.5	2.97	94.60	0	0	0	2.
2001	334	0	442	14.122	-22.824	D	5.318	1.96	3.358	2.5	2.26	91.91	0	0	0	5.
2001	344	0	442	14.122	-22.824	D	5.24	1.96	3.28	2.4	2.34	95.51	0	0	0	2.
2001	326	0	443	15.436	-22.821	D	4.966	1.96	3.007	2.5	2.08	93.77	0	0	0	4.
2001	44	0	636	-5.564	-1.341	D	4.924	1.96	2.964	2.3	1.99	94.65	0	0	0	3.
2001	55	0	442	14.122	-22.824	D	4.739	1.96	2.779	2.3	4.01	93.23	0	0	0	2.
2001	80	0	343	25.989	-33.535	D	4.638	1.96	2.678	2.3	2.03	93.10	0	0	0	4.
2001	322	0	343	25.989	-33.535	D	4.613	1.96	2.653	2.5	1.82	94.00	0	0	0	4.
2001	333	0	343	25.989	-33.535	D	4.471	1.96	2.512	2.5	1.49	93.98	0	0	0	4.
2001	315	0	442	14.122	-22.824	D	4.372	1.96	2.412	2.5	1.70	94.71	0	0	0	3.
2001	43	0	442	14.122	-22.824	D	4.356	1.96	2.396	2.3	1.44	95.03	0	0	0	3.
2001	96	0	392	23.337	-28.171	D	4.276	1.96	2.317	2.1	2.17	92.83	0	0	0	5
2001	324	0	343	25.989	-33.535	D	4.247	1.96	2.287	2.5	1.24	95.23	0	0	0	3.
2001	45	0	442	14.122	-22.824	D	4.093	1.96	2.134	2.3	2.02	95.56	0	0	0	2.
2001	46	0	343	25.989	-33.535	D	4.074	1.96	2.114	2.3	2.69	94.61	0	0	0	2.
2001	63	0	638	-2.946	-1.343	D	4.004	1.96	2.045	2.3	2.24	95.27	0	0	0	2.
2001	10	0	442	14.122	-22.824	D	3.925	1.96	1.965	2.5	1.55	95.81	0	0	0	2.
2001	97	0	735	-10.785	7.622	D	3.916	1.96	1.957	2.1	3.43	94.10	0	0	0	2.
2001	98	0	442	14.122	-22.824	D	3.869	1.96	1.909	2.1	2.30	93.89	0	0	0	3.
2001	354	0	442	14.122	-22.824	D	3.839	1.96	1.879	2.4	2.97	92.93	0	0	0	4.
2001	279	0	343	25.989	-33.535	D	3.798	1.96	1.838	2	1.04	88.59	0	0	0	10.
2001	310	0	442	14.122	-22.824	D	3.766	1.96	1.806	2.5	1.31	92.98	0	0	0	5.
2001	9	0	636	-5.564	-1.341	D	3.717	1.96	1.757	2.5	1.62	96.50	0	0	0	1.
2001	314	0	343	25.989	-33.535	D	3.717	1.96	1.757	2.5	1.71	94.97	0	0	0	3.
2001	81	0	343	25.989	-33.535	D	3.642	1.96	1.682	2.3	1.10	94.57	0	0	0	4.
2001	338	0	409	23.331	-26.379	D	3.622	1.96	1.662	2.4	2.91	91.70	0	0	0	5.

2001	11	0	343	25.989	-33.535	D	3.609	1.96	1.649	2.5	1.70	93.39	0	0	0	4.
2001	105	0	343	25.989	-33.535	D	3.608	1.96	1.649	2.1	1.60	92.45	0	0	0	5.
2001	349	0	636	-5.564	-1.341	D	3.594	1.96	1.634	2.4	2.22	90.55	0	0	0	7.
2001	104	0	442	14.122	-22.824	D	3.572	1.96	1.612	2.1	0.66	93.49	0	0	0	5.
2001	79	0	343	25.989	-33.535	D	3.566	1.96	1.606	2.3	0.98	92.36	0	0	0	6.
2001	41	0	343	25.989	-33.535	D	3.563	1.96	1.603	2.3	2.01	94.23	0	0	0	3.
2001	321	0	343	25.989	-33.535	D	3.496	1.96	1.536	2.5	1.78	93.96	0	0	0	4.
2001	301	0	442	14.122	-22.824	D	3.476	1.96	1.516	2	1.53	88.40	0	0	0	10.
2001	49	0	343	25.989	-33.535	D	3.437	1.96	1.477	2.3	1.25	95.65	0	0	0	3.
2001	51	0	442	14.122	-22.824	D	3.388	1.96	1.428	2.3	3.61	93.22	0	0	0	3.
2001	318	0	442	14.122	-22.824	D	3.352	1.96	1.392	2.5	2.53	93.74	0	0	0	3.
2001	112	0	442	14.122	-22.824	D	3.35	1.96	1.39	2.1	1.17	93.45	0	0	0	5.
2001	313	0	343	25.989	-33.535	D	3.348	1.96	1.388	2.5	1.60	95.25	0	0	0	3.
2001	156	0	377	25.974	-29.952	D	3.338	1.96	1.378	1.8	0.69	79.91	0	0	0	19.
2001	65	0	343	25.989	-33.535	D	3.33	1.96	1.37	2.3	1.22	95.67	0	0	0	3.
2001	311	0	636	-5.564	-1.341	D	3.249	1.96	1.289	2.5	1.77	93.61	0	0	0	4.
2001	61	0	343	25.989	-33.535	D	3.241	1.96	1.281	2.3	1.93	96.06	0	0	0	2.
2001	42	0	636	-5.564	-1.341	D	3.236	1.96	1.276	2.3	2.55	94.25	0	0	0	3.
2001	62	0	343	25.989	-33.535	D	3.188	1.96	1.229	2.3	1.90	95.87	0	0	0	2.
2001	346	0	276	51.107	-47.717	D	3.183	1.96	1.223	2.4	2.55	94.96	0	0	0	2.
2001	54	0	343	25.989	-33.535	D	3.169	1.96	1.209	2.3	1.86	94.51	0	0	0	3.
2001	352	0	442	14.122	-22.824	D	3.145	1.96	1.185	2.4	2.93	92.85	0	0	0	4.
2001	250	0	636	-5.564	-1.341	D	3.127	1.96	1.167	1.8	0.92	86.57	0	0	0	12.
2001	320	0	343	25.989	-33.535	D	3.093	1.96	1.133	2.5	2.76	93.19	0	0	0	4.
2001	50	0	343	25.989	-33.535	D	3.092	1.96	1.132	2.3	1.11	94.51	0	0	0	4.
2001	69	0	636	-5.564	-1.341	D	3.079	1.96	1.119	2.3	1.70	96.24	0	0	0	2.
2001	345	0	636	-5.564	-1.341	D	3.071	1.96	1.111	2.4	2.15	96.03	0	0	0	1.
2001	85	0	392	23.337	-28.171	D	3.069	1.96	1.109	2.3	2.96	95.00	0	0	0	2.
2001	84	0	636	-5.564	-1.341	D	3.058	1.96	1.098	2.3	2.40	94.40	0	0	0	3.
2001	304	0	636	-5.564	-1.341	D	3.027	1.96	1.067	2	1.52	88.01	0	0	0	10.
										Average	**1.96**	**93.58**	**0.00**	**0.00**	**0.00**	**4.**

Unfortunately, BLM did not report secondary aerosol concentrations in the TSD. Presentation of that information is very important because it enables review of the individual species that contribute to visibility impairment without the uncertainty of the assumptions used to convert concentrations into visual range. In the future BLM needs to provide more complete information so that reviewers can better interpret the modeling results. As a result of this serious deficiency, BP conducted a limited evaluation of secondary NO_3 for each day and the receptor that had the highest visibility impacts for the 2005 actual case. In the BP analysis the only thing that was changed from what TRC performed was that impacts at only receptor 134 (one of the receptors with highest impact from the TRC modeling) were modeled. In addition, the option for printed 24-hour concentrations of NO_3 in the output file was turned on. As in the TRC modeling, 18 separate modeling runs were made. The 24-hour predicted NO_3 concentrations for each day of the year were extracted and input into an EXCEL Workbook where the results were combined into total daily NO_3 concentrations. This approach was used in order to bypass the CALPUFF post processing programs and obtain the desired output of daily concentrations. Table 2 presents a listing of the combined daily NO_3 concentrations and indicates that the maximum **predicted** NO_3 concentration as a result of oil and gas operation in 2005 was 5.3 ug/m^3.

The 2005 Bridger **monitored** NO_3 concentration data were obtained from the IMPROVE web site and the maximum measured concentration was 0.12 ug/m^3 (Table 3). In actuality this was the lowest NO_3 concentration at the Bridger monitoring site over the period of 1988 through 2005. This provides a strong indication that CALPUFF is substantially over predicting NO_3 concentrations at the Bridger Class I Area.
There are minor limitations to the BP analysis such as the unavailability of 2005 meteorological data therefore requiring the use of 2001 meteorology. As a result, it is not possible to compare specific days of model output with days that monitoring data were collected. Changes in meteorology alone are not likely to cause such a large model over prediction. A second minor limitation is that since the IMPROVE data are only collected every 3 days, high NO_3 occurred on days when sampling was not collected. This possibility was examined by reviewing NO_3 concentrations over the period of record

(1998-2005). Over this period the maximum NO_3 concentration was 0.82 ug/m^3 (in 2002). Clearly, as a result of this comparison there is a very strong indication that CALPUFF is substantially over predicting measured NO_3 concentrations.

Table 2. Predicted NO_3 Concentrations for Maximum Receptor
model run = total

				ug/m^3			
Day	Receptor No.	SO4	NOX	HNO3	NO3	PMC	PM25
2	1	0.0000	0.8750	0.0016	0.0000	0.4439	0.1178
3	1	0.0019	61.7529	0.2106	0.1351	1.2939	2.3527
4	1	0.0013	20.6177	0.0648	0.0563	1.0807	0.9396
5	1	0.0014	35.0763	0.0906	0.1348	1.0765	1.5042
6	1	0.0014	14.8265	0.0191	0.2005	1.4352	0.9775
7	1	0.0000	0.4504	0.0005	0.0000	0.2335	0.0600
8	1	0.0010	2.9012	0.0109	0.0329	1.6465	0.4075
9	1	0.0006	3.3240	0.0217	0.0311	1.7378	0.4985
10	1	0.0035	3.1180	0.0113	0.3364	1.2555	0.4465
11	1	0.0000	3.1007	0.0107	0.0005	1.7619	0.4286
12	1	0.0001	4.4014	0.0267	0.0001	2.4980	0.6200
13	1	0.0005	3.8657	0.0034	0.0494	0.6421	0.2814
14	1	0.0008	11.6041	0.0389	0.0512	1.6278	0.6793
15	1	0.0000	0.5023	0.0006	0.0000	0.2611	0.0671
16	1	0.0000	0.5590	0.0006	0.0002	0.2946	0.0745
17	1	0.0000	0.8271	0.0012	0.0000	0.4480	0.1111
18	1	0.0000	1.2263	0.0025	0.0000	0.6604	0.1657
19	1	0.0000	0.9154	0.0018	0.0000	0.4761	0.1237
20	1	0.0009	8.6099	0.0360	0.1058	2.6550	1.0139
21	1	0.0000	0.9479	0.0018	0.0009	0.4571	0.1223
22	1	0.0007	10.1475	0.0522	0.0662	2.1633	0.7627
23	1	0.0001	0.8396	0.0010	0.0039	0.4562	0.1127
24	1	0.0007	2.5537	0.0091	0.0496	1.4429	0.3578
25	1	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000
26	1	0.0045	92.3846	0.2561	0.0524	1.1832	4.6496
27	1	0.0000	0.9938	0.0015	0.0007	0.5478	0.1334
28	1	0.0000	0.5441	0.0007	0.0002	0.2903	0.0728
29	1	0.0000	0.7714	0.0014	0.0004	0.3995	0.1036
30	1	0.0007	36.1962	0.1225	0.0276	0.6607	1.2768
31	1	0.0009	44.4349	0.1434	0.0364	0.8569	1.5988
32	1	0.0020	45.4411	0.0998	0.0501	1.0969	2.3621
33	1	0.0014	23.4821	0.0655	0.0497	0.8571	1.2889
34	1	0.0001	4.0001	0.0180	0.0001	0.7449	0.3821
35	1	0.0030	105.0897	0.5655	0.0827	1.9646	3.6912
36	1	0.0000	3.1767	0.0135	0.0025	1.7857	0.4395
37	1	0.0002	9.9034	0.0563	0.0031	1.5853	0.6073
38	1	0.0008	0.9327	0.0013	0.0196	0.5111	0.1256
39	1	0.0039	16.8757	0.0894	0.1748	1.7636	1.6081
40	1	0.0004	2.3733	0.0072	0.0050	1.3456	0.3268
41	1	0.0058	85.1691	0.7064	0.0804	1.9209	7.9876

42	1	0.0001	2.4897	0.0111	0.0015	1.4026	0.3424
43	1	0.0030	9.6403	0.1004	0.3290	5.2539	1.5228
44	1	0.0143	27.2949	0.1443	1.5302	4.9285	2.4595
45	1	0.0030	0.7836	0.0011	0.0732	0.4367	0.1165
46	1	0.0004	8.2218	0.0142	0.0263	0.9869	0.5672
47	1	0.0008	19.6073	0.1285	0.0635	3.3004	0.9016
48	1	0.0021	19.6932	0.0369	0.3029	2.1392	1.2745
49	1	0.0153	14.6720	0.0794	1.6914	6.3601	2.2890
50	1	0.0071	37.2346	0.2089	0.7860	4.6568	4.0298
51	1	0.0109	58.3462	0.6635	0.1648	4.0363	3.7428
52	1	0.0006	19.4845	0.0806	0.0439	2.3063	0.6765
53	1	0.0007	7.7765	0.0254	0.0452	2.2449	0.7329
54	1	0.0000	0.9986	0.0016	0.0001	0.5534	0.1342
55	1	0.0094	90.7257	0.2795	0.1383	1.0441	4.5113
56	1	0.0007	8.2338	0.0376	0.1186	3.2499	0.9353
57	1	0.0008	9.5200	0.0530	0.0844	2.7624	1.1087
58	1	0.0000	0.6471	0.0007	0.0001	0.3410	0.0864
59	1	0.0000	0.8193	0.0012	0.0001	0.4446	0.1101
60	1	0.0046	107.1102	0.2232	0.1453	1.5421	5.3972
61	1	0.0003	4.3024	0.0254	0.0212	2.4478	0.6107
62	1	0.0000	1.3182	0.0038	0.0000	0.7378	0.1799
63	1	0.0014	13.1512	0.1390	0.2840	6.9333	1.8619
64	1	0.0143	36.4094	0.5688	1.0991	6.8572	2.4322
65	1	0.0000	1.3615	0.0029	0.0004	0.7406	0.1848
66	1	0.0000	0.5038	0.0006	0.0001	0.2666	0.0673
67	1	0.0000	0.7587	0.0010	0.0005	0.4094	0.1019
68	1	0.0003	1.5622	0.0038	0.0077	0.8589	0.2139
69	1	0.0007	0.7881	0.0018	0.0310	0.4296	0.1094
70	1	0.0183	24.7210	0.0107	1.9869	1.6490	1.6195
71	1	0.0009	39.9410	0.1346	0.0474	0.7531	1.4534
72	1	0.0001	6.0986	0.0183	0.0064	0.5414	0.3011
73	1	0.0007	6.5459	0.0341	0.0242	1.7388	0.5939
74	1	0.0000	1.0005	0.0019	0.0005	0.5014	0.1315
75	1	0.0000	0.7902	0.0014	0.0000	0.4383	0.1064
76	1	0.0001	0.7018	0.0009	0.0020	0.3751	0.0943
77	1	0.0000	0.7031	0.0012	0.0000	0.3687	0.0944
78	1	0.0000	1.2048	0.0022	0.0000	0.6369	0.1627
79	1	0.0006	12.0577	0.1527	0.0245	6.8444	1.7950
80	1	0.0004	5.5097	0.0214	0.0961	3.1081	0.7962
81	1	0.0061	156.9367	1.2719	0.0517	2.2845	5.2785
82	1	0.0000	2.2640	0.0062	0.0000	1.2669	0.3102
83	1	0.0002	0.6597	0.0010	0.0089	0.3489	0.0896
84	1	0.0009	3.1755	0.0168	0.0750	1.6277	0.4130
85	1	0.0006	3.5684	0.0101	0.0189	0.4728	0.2066
86	1	0.0011	14.7016	0.0477	0.0505	1.0514	0.9062
87	1	0.0013	21.6584	0.1242	0.0712	1.8629	1.0882
88	1	0.0001	3.8604	0.0121	0.0258	1.6934	0.4599
89	1	0.0003	5.7184	0.0052	0.0669	0.8366	0.3873
90	1	0.0000	1.1060	0.0019	0.0001	0.5694	0.1489
91	1	0.0006	17.8503	0.0983	0.0237	0.9922	0.4298

92	1	0.0000	1.1124	0.0022	0.0069	0.6084	0.1489
93	1	0.0004	20.2044	0.0946	0.0015	0.7803	0.7701
94	1	0.0000	0.0003	0.0000	0.0001	0.0000	0.0000
95	1	0.0000	1.6868	0.0064	0.0045	0.9225	0.2257
96	1	0.0001	3.0107	0.0132	0.0046	1.7120	0.4233
97	1	0.0018	19.0299	0.0757	0.0801	1.4935	1.1697
98	1	0.0028	1.8848	0.0051	0.3280	0.5180	0.2623
99	1	0.0001	3.3124	0.0151	0.0035	1.4217	0.3813
100	1	0.0000	0.9994	0.0017	0.0000	0.5383	0.1347
101	1	0.0000	0.9861	0.0016	0.0001	0.5097	0.1327
102	1	0.0000	0.5633	0.0008	0.0001	0.3136	0.0754
103	1	0.0000	1.9881	0.0054	0.0000	1.1038	0.2711
104	1	0.0052	49.4413	0.5734	0.1937	4.8055	5.0427
105	1	0.0000	0.8484	0.0013	0.0000	0.4597	0.1141
106	1	0.0000	0.7072	0.0009	0.0000	0.3780	0.0948
107	1	0.0000	0.4819	0.0005	0.0011	0.2623	0.0644
108	1	0.0000	1.8078	0.0046	0.0000	1.0187	0.2458
109	1	0.0003	0.8697	0.0090	0.0272	0.1151	0.0686
110	1	0.0000	0.5431	0.0009	0.0021	0.2954	0.0727
111	1	0.0034	40.6536	0.4830	0.0050	2.1611	3.8609
112	1	0.0002	0.7727	0.0014	0.0015	0.4267	0.1041
113	1	0.0000	1.4137	0.0018	0.0077	0.4452	0.1338
114	1	0.0000	1.4953	0.0034	0.0000	0.8173	0.2034
115	1	0.0000	1.0891	0.0019	0.0000	0.5689	0.1468
116	1	0.0002	0.7273	0.0013	0.0026	0.3878	0.0982
117	1	0.0000	1.3251	0.0024	0.0000	0.7409	0.1797
118	1	0.0027	9.0710	0.1907	0.1211	0.9604	0.5503
119	1	0.0006	7.2689	0.0448	0.0134	1.2463	0.5616
120	1	0.0003	18.2454	0.0636	0.0160	0.8248	0.6588
121	1	0.0000	2.1506	0.0073	0.0002	3.3235	0.9580
122	1	0.0000	1.3871	0.0024	0.0003	2.1391	0.6155
123	1	0.0000	0.9317	0.0011	0.0000	1.4166	0.4137
124	1	0.0000	1.2069	0.0015	0.0001	1.8900	0.5372
125	1	0.0042	8.8522	0.0563	0.2898	10.6314	3.1879
126	1	0.0010	20.1403	0.0442	0.0770	4.6852	2.2269
127	1	0.0000	1.1674	0.0018	0.0000	1.8224	0.5217
128	1	0.0008	8.5844	0.0327	0.0763	5.5733	1.8564
129	1	0.0011	15.1236	0.1572	0.0564	13.5237	4.5721
130	1	0.0007	9.1004	0.0429	0.0298	9.1740	2.7606
131	1	0.0000	2.2697	0.0047	0.0000	3.6130	1.0259
132	1	0.0000	1.5990	0.0033	0.0000	2.4411	0.7193
133	1	0.0015	9.7750	0.1695	0.1331	15.1365	4.6156
134	1	0.0000	3.8331	0.0146	0.0012	6.1165	1.7544
135	1	0.0000	2.0350	0.0057	0.0001	2.3185	0.7175
136	1	0.0000	4.2150	0.0133	0.0025	4.2658	1.2008
137	1	0.0023	31.6316	0.1109	0.0995	6.0469	3.1056
138	1	0.0003	8.4054	0.0447	0.0340	9.9127	2.9939
139	1	0.0000	1.9642	0.0044	0.0000	3.0650	0.8863
140	1	0.0005	7.3035	0.0321	0.0114	3.5529	1.2252
141	1	0.0000	1.3197	0.0023	0.0002	2.0837	0.5904

142	1	0.0012	14.4130	0.0541	0.1107	5.4280	2.1483
143	1	0.0000	1.5899	0.0033	0.0003	2.3959	0.7088
144	1	0.0000	0.9418	0.0011	0.0000	1.4345	0.4187
145	1	0.0000	1.4145	0.0020	0.0000	2.2406	0.6298
146	1	0.0000	0.8344	0.0009	0.0000	1.3054	0.3704
147	1	0.0001	4.9178	0.0220	0.0002	7.9319	2.2640
148	1	0.0001	0.0029	0.0009	0.0018	0.0027	0.0017
149	1	0.0056	139.8094	0.9795	0.1701	10.7884	7.2192
150	1	0.0000	1.9723	0.0060	0.0016	2.9699	0.8637
151	1	0.0000	1.6304	0.0040	0.0017	2.2738	0.6748
152	1	0.0000	1.8114	0.0039	0.0000	2.8344	0.8169
153	1	0.0037	20.3827	0.6696	0.1279	27.2164	8.8712
154	1	0.0002	2.4607	0.0163	0.0257	3.3226	1.0110
155	1	0.0000	3.5101	0.0155	0.0011	5.7031	1.6228
156	1	0.0001	4.1491	0.0179	0.0062	6.7347	1.9303
157	1	0.0003	7.1375	0.0477	0.0407	9.9628	2.8945
158	1	0.0000	1.7453	0.0048	0.0011	2.5897	0.7576
159	1	0.0000	2.8634	0.0086	0.0000	4.6244	1.2993
160	1	0.0001	6.5975	0.0518	0.0005	10.7323	3.1001
161	1	0.0000	3.0422	0.0080	0.0000	4.8965	1.3874
162	1	0.0010	14.2765	0.1570	0.0356	8.9920	2.9259
163	1	0.0056	102.1895	0.3690	0.0201	5.6147	6.4066
164	1	0.0011	13.1881	0.0540	0.0306	3.7745	1.5237
165	1	0.0015	43.6955	0.0831	0.0279	2.5192	2.7869
166	1	0.0001	6.1598	0.0286	0.0023	9.9144	2.8441
167	1	0.0000	3.3559	0.0093	0.0000	5.4099	1.5312
168	1	0.0001	8.1020	0.0759	0.0026	6.8153	1.9439
169	1	0.0030	18.2851	0.2162	0.0960	11.3664	3.8074
170	1	0.0000	1.1070	0.0014	0.0000	1.7195	0.4927
171	1	0.0027	1.0216	0.0214	0.0224	1.6001	0.4788
172	1	0.0001	1.1254	0.0018	0.0006	1.7549	0.5009
173	1	0.0002	1.2667	0.0036	0.0008	1.9938	0.5687
174	1	0.0000	2.3154	0.0057	0.0000	3.7377	1.0466
175	1	0.0001	5.1104	0.0360	0.0025	8.3631	2.4126
176	1	0.0210	88.3171	1.3960	0.5173	12.7738	7.6480
177	1	0.0001	0.9109	0.0176	0.0037	1.3444	0.3948
178	1	0.0031	25.9022	0.2518	0.0325	6.3204	2.8977
179	1	0.0123	16.8980	0.7257	0.1655	6.4914	2.8382
180	1	0.0000	2.1468	0.0053	0.0000	3.4019	0.9745
181	1	0.0000	1.3961	0.0023	0.0000	2.2139	0.6252
182	1	0.0003	0.7627	0.0197	0.0032	1.1849	0.3418
183	1	0.0000	1.3183	0.0022	0.0000	2.0746	0.5910
184	1	0.0000	1.0841	0.0014	0.0000	1.6811	0.4827
185	1	0.0000	0.7212	0.0008	0.0000	1.0790	0.3193
186	1	0.0010	1.1060	0.0077	0.0015	1.7292	0.4995
187	1	0.0003	5.9356	0.0567	0.0074	4.7561	1.4897
188	1	0.0000	3.2132	0.0126	0.0003	5.1419	1.4632
189	1	0.0000	3.4294	0.0103	0.0003	5.3844	1.5383
190	1	0.0000	1.4744	0.0022	0.0000	2.3385	0.6588
191	1	0.0006	1.9644	0.0238	0.0212	3.1057	0.8785

192	1	0.0011	8.0458	0.0873	0.0535	12.9446	3.8552
193	1	0.0000	2.1066	0.0051	0.0003	3.3992	0.9526
194	1	0.0014	1.0406	0.0222	0.0152	1.6767	0.4767
195	1	0.0001	0.0008	0.0009	0.0001	0.0014	0.0009
196	1	0.0032	4.4916	0.1366	0.0529	5.9009	2.2430
197	1	0.0005	6.1710	0.0529	0.1046	10.2159	3.0544
198	1	0.0001	4.4494	0.0350	0.0026	7.2468	2.0972
199	1	0.0093	31.6441	0.6299	0.1392	21.2041	7.1895
200	1	0.0000	1.9863	0.0047	0.0003	3.2012	0.8969
201	1	0.0007	2.8001	0.0404	0.0494	4.0081	1.1808
202	1	0.0048	31.1676	1.1294	0.1528	46.8469	15.5662
203	1	0.0042	52.7453	0.9512	0.0822	35.3644	11.5662
204	1	0.0000	1.2400	0.0018	0.0000	1.9468	0.5540
205	1	0.0001	2.3678	0.0112	0.0014	2.8493	0.8506
206	1	0.0000	3.6562	0.0127	0.0001	5.9501	1.6836
207	1	0.0000	3.3041	0.0090	0.0000	5.3034	1.5102
208	1	0.0043	152.8438	0.9081	0.0098	5.9978	6.2058
209	1	0.0000	2.5828	0.0111	0.0006	4.1119	1.1558
210	1	0.0009	14.2789	0.1176	0.0166	4.8255	1.8954
211	1	0.0000	2.2369	0.0053	0.0000	3.6142	1.0111
212	1	0.0026	17.2728	0.2591	0.0588	6.6849	2.5774
213	1	0.0000	4.1386	0.0145	0.0006	6.6243	1.8766
214	1	0.0000	1.6924	0.0040	0.0000	2.6236	0.7650
215	1	0.0000	1.6398	0.0033	0.0000	2.6275	0.7352
216	1	0.0001	3.7395	0.0198	0.0021	6.0417	1.7328
217	1	0.0002	9.8540	0.0737	0.0015	13.9683	4.1583
218	1	0.0000	1.1309	0.0016	0.0000	1.7482	0.5049
219	1	0.0013	1.3770	0.0107	0.0018	2.1902	0.6240
220	1	0.0014	1.3774	0.0099	0.0018	2.0940	0.6234
221	1	0.0000	0.8597	0.0009	0.0000	1.3382	0.3806
222	1	0.0071	28.4767	0.3428	0.2699	5.9431	3.2122
223	1	0.0000	2.6831	0.0078	0.0000	4.2959	1.2270
224	1	0.0000	2.3758	0.0056	0.0000	3.8432	1.0776
225	1	0.0019	0.0029	0.0181	0.0046	0.0215	0.0153
226	1	0.0003	4.7154	0.0481	0.0079	3.4461	1.0850
227	1	0.0000	2.4882	0.0062	0.0000	4.0161	1.1250
228	1	0.0000	1.7418	0.0030	0.0000	2.7840	0.7833
229	1	0.0000	1.2420	0.0019	0.0000	1.9517	0.5550
230	1	0.0000	0.8449	0.0014	0.0001	1.3332	0.3755
231	1	0.0012	13.6241	0.1447	0.0208	5.2444	2.0448
232	1	0.0004	15.8566	0.0997	0.0042	7.5075	2.4668
233	1	0.0005	7.9513	0.0641	0.0672	10.2752	3.0237
234	1	0.0109	28.8071	0.3434	0.8284	26.4023	9.3707
235	1	0.0158	100.4925	1.3944	0.4523	13.1785	12.7142
236	1	0.0001	4.2790	0.0194	0.0008	6.6851	1.8965
237	1	0.0000	1.5684	0.0043	0.0001	2.3777	0.6992
238	1	0.0000	1.5294	0.0029	0.0000	2.3947	0.6875
239	1	0.0000	1.0767	0.0013	0.0000	1.6624	0.4792
240	1	0.0000	1.8029	0.0038	0.0000	2.8037	0.8121
241	1	0.0000	2.4579	0.0075	0.0002	3.8673	1.1078

242	1	0.0005	2.0130	0.0239	0.0244	3.0406	0.8783
243	1	0.0042	20.4636	0.4118	0.0929	14.0162	4.6642
244	1	0.0052	113.1051	1.0502	0.0776	12.7074	6.8148
245	1	0.0007	12.9811	0.1121	0.0110	12.0148	3.9796
246	1	0.0001	4.1065	0.0185	0.0002	6.6551	1.8936
247	1	0.0001	2.9476	0.0108	0.0008	4.7609	1.3403
248	1	0.0020	17.9378	0.4768	0.0701	28.9733	8.9507
249	1	0.0157	21.8228	0.5637	0.8269	19.7604	7.1462
250	1	0.0004	9.9721	0.0290	0.0134	2.3087	1.1984
251	1	0.0000	0.8173	0.0011	0.0000	1.2613	0.3631
252	1	0.0030	23.2429	0.1302	0.0897	7.4254	2.9011
253	1	0.0040	20.4504	0.1867	0.2448	13.6908	4.4921
254	1	0.0002	7.5352	0.0762	0.0165	12.2931	3.5706
255	1	0.0003	0.0982	0.0116	0.0175	0.0489	0.0279
256	1	0.0013	5.8244	0.1702	0.0258	4.5157	1.6109
257	1	0.0291	58.2700	0.9660	1.5057	17.3271	8.8474
258	1	0.0166	33.0847	0.2767	1.5612	11.7153	5.0545
259	1	0.0014	16.0642	0.1948	0.2089	20.7978	6.1819
260	1	0.0001	0.9368	0.0021	0.0005	1.4607	0.4183
261	1	0.0002	1.8732	0.0061	0.0040	3.0312	0.8520
262	1	0.0022	27.3702	0.2354	0.1445	12.7201	4.3419
263	1	0.0007	14.4468	0.0655	0.0099	6.5522	2.4510
264	1	0.0002	6.7699	0.0402	0.0130	10.4206	2.9691
265	1	0.0048	74.6154	0.3112	0.0231	7.5773	5.4807
266	1	0.0003	0.2341	0.0084	0.0261	0.0637	0.0333
267	1	0.0023	5.1929	0.1346	0.1507	8.6313	3.6043
268	1	0.0003	2.6939	0.0170	0.0089	4.2959	1.2161
269	1	0.0035	16.8341	0.3758	0.0936	17.2980	5.4796
270	1	0.0003	9.0011	0.0701	0.0004	14.8201	4.4159
271	1	0.0215	104.4219	1.3592	0.0094	6.1561	6.6351
272	1	0.0000	2.1950	0.0049	0.0000	3.5356	0.9881
273	1	0.0007	0.9537	0.0090	0.0079	1.5228	0.4345
274	1	0.0000	0.0002	0.0001	0.0002	0.0001	0.0001
275	1	0.0013	22.4302	0.0907	0.0123	5.5339	2.5196
276	1	0.0015	13.0856	0.0926	0.0568	7.8042	2.6308
277	1	0.0001	2.7752	0.0094	0.0069	4.3175	1.2155
278	1	0.0096	11.0976	0.0281	0.9272	2.4054	1.3682
279	1	0.0438	64.2802	1.1061	2.6696	43.4989	15.5331
280	1	0.0000	3.3704	0.0118	0.0022	5.3604	1.5280
281	1	0.0010	30.5858	0.1316	0.0005	3.4296	3.5557
282	1	0.0002	4.0382	0.0158	0.0149	3.2992	1.1037
283	1	0.0031	59.5680	0.1766	0.0353	5.1670	4.1675
284	1	0.0000	3.6016	0.0118	0.0012	5.4352	1.5475
285	1	0.0006	24.5523	0.0572	0.0428	2.2991	1.5346
286	1	0.0000	4.7996	0.0124	0.0022	3.7061	1.1475
287	1	0.0001	2.6096	0.0101	0.0051	3.3117	0.9926
288	1	0.0003	12.5261	0.0466	0.0256	3.7135	1.4054
289	1	0.0024	60.5170	0.4921	0.1037	14.4934	5.7328
290	1	0.0063	18.1650	0.2084	0.5001	19.0989	6.2464
291	1	0.0009	13.4871	0.0526	0.0211	3.6796	1.4490

292	1	0.0010	10.9430	0.0451	0.0306	3.8165	1.4843
293	1	0.0000	3.1901	0.0107	0.0042	4.8442	1.4389
294	1	0.0000	3.4492	0.0112	0.0003	5.5881	1.5808
295	1	0.0000	3.8026	0.0118	0.0002	5.8023	1.6357
296	1	0.0012	33.3438	0.1610	0.0016	3.7326	3.8734
297	1	0.0004	9.3455	0.0312	0.0089	1.8684	0.7950
298	1	0.0006	8.5599	0.0388	0.0306	9.5844	2.8372
299	1	0.0012	14.8879	0.0662	0.0640	4.8687	1.9609
300	1	0.0080	22.4583	0.1703	0.7791	27.2386	8.8187
301	1	0.0001	6.6450	0.0333	0.0081	10.7910	3.0887
302	1	0.0182	47.6775	0.5664	0.8082	22.6927	8.5546
303	1	0.0195	47.8715	0.8685	0.7409	17.8657	7.7734
304	1	0.0000	1.4302	0.0032	0.0004	2.0680	0.6395
305	1	0.0001	4.7023	0.0147	0.0000	0.4451	0.4566
306	1	0.0012	11.5195	0.0452	0.0446	1.1656	0.6619
307	1	0.0000	2.6949	0.0081	0.0001	1.5245	0.3710
308	1	0.0032	0.0215	0.0055	0.1150	0.0155	0.0226
309	1	0.0121	25.4467	0.2461	1.0940	8.8757	3.2114
310	1	0.0046	14.7497	0.1931	0.4701	8.1335	2.2784
311	1	0.0007	6.6243	0.0395	0.0474	1.6314	0.7430
312	1	0.0004	1.8078	0.0039	0.0434	0.9115	0.2417
313	1	0.0042	13.7685	0.1250	0.6416	7.3983	2.1185
314	1	0.0001	4.2244	0.0266	0.0094	2.4002	0.5914
315	1	0.0489	56.5244	0.5314	4.0076	4.6381	4.1490
316	1	0.0001	4.0140	0.0180	0.0131	2.2742	0.5588
317	1	0.0000	1.5804	0.0091	0.0073	0.9023	0.2246
318	1	0.0015	39.8034	0.1826	0.0875	1.5886	1.6439
319	1	0.0000	2.4267	0.0065	0.0000	1.3569	0.3325
320	1	0.0383	41.9642	0.2753	3.6977	8.8853	4.3287
321	1	0.0069	23.4667	0.2970	0.8918	13.2254	3.9363
322	1	0.0049	7.0322	0.0488	0.5900	3.3852	1.0345
323	1	0.0031	8.3766	0.0380	0.2578	3.6084	1.1111
324	1	0.0015	20.7181	0.1159	0.1084	2.3041	1.2203
325	1	0.0001	5.2562	0.0251	0.0115	2.9834	0.7367
326	1	0.0087	59.8440	0.5638	1.1286	4.0640	2.6686
327	1	0.0000	2.5665	0.0098	0.0024	1.4212	0.3516
328	1	0.0020	36.4808	0.1011	0.0638	1.0381	1.9441
329	1	0.0000	0.9153	0.0027	0.0001	0.5098	0.1239
330	1	0.0032	91.8069	0.1946	0.0193	0.9350	4.5345
331	1	0.0559	25.4025	0.0276	5.2719	2.3232	2.8668
332	1	0.0339	56.0690	0.5652	3.2180	3.8752	3.9265
333	1	0.0017	12.6116	0.0384	0.2199	2.2927	1.3810
334	1	0.0003	7.5333	0.0464	0.0331	2.6342	0.6742
335	1	0.0000	2.3603	0.0068	0.0006	1.3224	0.3223
336	1	0.0003	3.0664	0.0056	0.0297	0.7993	0.2957
337	1	0.0001	3.8396	0.0133	0.0068	0.7795	0.4129
338	1	0.0045	37.1237	0.2009	0.2751	3.3751	1.4586
339	1	0.0000	1.7710	0.0072	0.0015	0.8954	0.2211
340	1	0.0000	8.1298	0.0178	0.0002	0.1582	0.0481
341	1	0.0001	9.6747	0.0315	0.0043	1.6077	0.4101

342	1	0.0003	6.2667	0.0206	0.0217	0.8680	0.5522
343	1	0.0008	12.9456	0.1100	0.1280	6.6153	1.7596
344	1	0.0010	2.9965	0.0111	0.0329	1.7004	0.4189
345	1	0.0294	41.9499	0.1301	3.1833	6.9490	3.5097
346	1	0.0000	0.8799	0.0021	0.0006	0.4646	0.1173
347	1	0.0002	6.7481	0.0220	0.0095	0.6961	0.4707
348	1	0.0000	2.4239	0.0103	0.0020	1.1611	0.3163
349	1	0.0003	6.0892	0.0292	0.0133	1.8489	0.5475
350	1	0.0012	29.8015	0.0578	0.0605	1.1994	1.6351
351	1	0.0002	5.2846	0.0192	0.0299	2.6962	0.7102
352	1	0.0005	9.7798	0.0490	0.0251	1.1236	0.8368
353	1	0.0036	21.3652	0.1028	0.4162	2.5907	2.2225
354	1	0.0094	47.9310	0.1487	1.4020	3.8458	3.5603
355	1	0.0000	0.0004	0.0000	0.0001	0.0000	0.0000
356	1	0.0001	2.8557	0.0052	0.0136	1.0121	0.3092
357	1	0.0000	2.0213	0.0049	0.0001	1.1202	0.2753
358	1	0.0000	1.3395	0.0030	0.0000	0.7359	0.1815
359	1	0.0000	1.2016	0.0023	0.0000	0.6390	0.1620
360	1	0.0000	1.4917	0.0029	0.0001	0.8343	0.2024
361	1	0.0002	4.5028	0.0144	0.0343	1.9545	0.5107
362	1	0.0010	19.8959	0.0652	0.0259	1.1889	1.3499
363	1	0.0010	24.1417	0.0564	0.0700	2.5370	1.5640
364	1	0.0005	2.7570	0.0107	0.0210	1.5487	0.3786
365	1	0.0004	3.1367	0.0171	0.0148	1.6489	0.4129
	Max	0.0559	156.9367	1.3960	5.2719	46.8469	15.5662
	Min	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
	Average	0.0024	14.1372	0.1084	0.1567	4.3179	1.7602
	Sigma	0.0064	23.9575	0.2309	0.5372	5.8710	2.2791

Table 3. 2005 Bridger IMPROVE Monitoring Data

Date	NO3 (ug/m^3)
01/01/2005	0.073
01/04/2005	0.155
01/07/2005	0.096
01/10/2005	0.016
01/13/2005	0.066
01/16/2005	0.025
01/22/2005	0.025
01/25/2005	0.031
01/28/2005	0.053
01/31/2005	0.033
02/03/2005	0.020
02/06/2005	0.195
02/09/2005	0.561
02/12/2005	0.026
02/15/2005	0.155
02/18/2005	0.017
02/21/2005	0.018
02/24/2005	0.035
02/27/2005	0.173
03/02/2005	0.058
03/05/2005	0.146
03/08/2005	0.190
03/11/2005	0.168
03/14/2005	0.070
03/17/2005	0.271
03/20/2005	0.248
03/23/2005	0.025
03/26/2005	0.092
03/29/2005	0.076
04/01/2005	0.074
04/04/2005	0.362
04/07/2005	0.141
04/10/2005	0.064
04/13/2005	0.255
04/16/2005	0.129
04/19/2005	0.142
04/22/2005	0.128
04/25/2005	0.147
04/28/2005	0.032
05/01/2005	0.165
05/04/2005	0.142
05/07/2005	0.061
05/10/2005	0.113
05/13/2005	0.063
05/16/2005	0.164
05/19/2005	0.089
05/22/2005	0.038
05/25/2005	0.091
05/28/2005	0.033
05/31/2005	0.087
06/03/2005	0.048
06/06/2005	0.146
06/09/2005	0.031
06/12/2005	0.118
06/15/2005	0.063
06/18/2005	0.124
06/21/2005	0.079
06/24/2005	0.180
06/27/2005	0.007
07/15/2005	0.040
08/14/2005	0.046
09/07/2005	0.078
09/10/2005	0.164

09/13/2005	0.185
09/16/2005	0.142
09/19/2005	0.039
09/22/2005	0.040
09/25/2005	0.159
10/07/2005	0.055
10/10/2005	0.048
10/13/2005	0.018
10/16/2005	0.133
10/19/2005	0.0824
10/22/2005	0.021
10/25/2005	0.039
10/28/2005	0.139
10/31/2005	0.075
11/03/2005	0.068
11/06/2005	0.043
11/09/2005	0.018
11/12/2005	0.073
11/15/2005	0.039
11/18/2005	0.025
11/21/2005	0.017
11/27/2005	0.016
11/30/2005	0.135
12/03/2005	0.063
12/06/2005	0.110
12/09/2005	0.005
12/12/2005	0.012
12/15/2005	0.023
12/18/2005	0.112
12/21/2005	0.017
12/27/2005	0.027
12/30/2005	0.072
Maximum	**0.561**

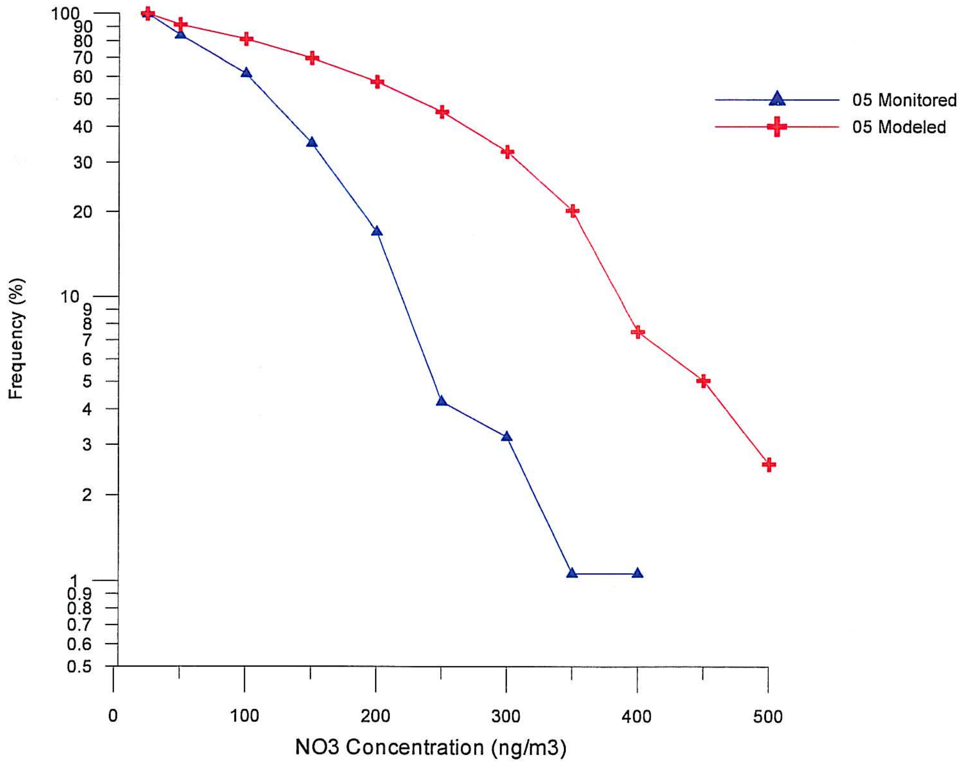

Figure 2. Cumulative Frequency Distribution for Bridger Class I Area NO3 Concentrations Modeled versus Monitored 1988-2005

It appears that the magnitude of the CALPUFF over prediction is in the range of a factor of 6 to 35 and a model having such a magnitude of over prediction CANNOT be used to forecast future conditions. Unfortunately, BLM has chosen to ignore the recommendations previously made by BP to identify model performance and unless between draft and final a thorough model evaluation is conducted, the modeling results will mislead the public regarding potential impacts of development and will result in improper environmental management policies.

Because the above comparison focused simply on the highest predicted and measured NO_3 concentrations, care must be exercised to ensure that such a comparison is not affected by outliers. In order to address this issue, a comparison of 2005 monitored NO_3 frequency distributions was compared to the 2005 modeled frequency distribution (Figure 2). This figure demonstrates that the NO_3 frequency distribution for the monitoring data is substantially lower than the NO_3 frequency distribution for the modeling results. This again indicates that CALPUFF is not accurately replicating observed concentrations. The fact that the CALPUFF model is not replicating any portion of the frequency distribution is a very strong indication that the any differences between monitor location and maximum receptor or sampling interval are not significant, but rather inaccuracy in the model formulation and application. Figure 3 presents the frequency distribution for all measured NO_3 concentrations over the period or record (1988 through 2005) and demonstrates that the frequency distributions for all years of monitoring data are similar. This clearly illustrates that 2005 monitoring data are consistent with measurements made during other years.

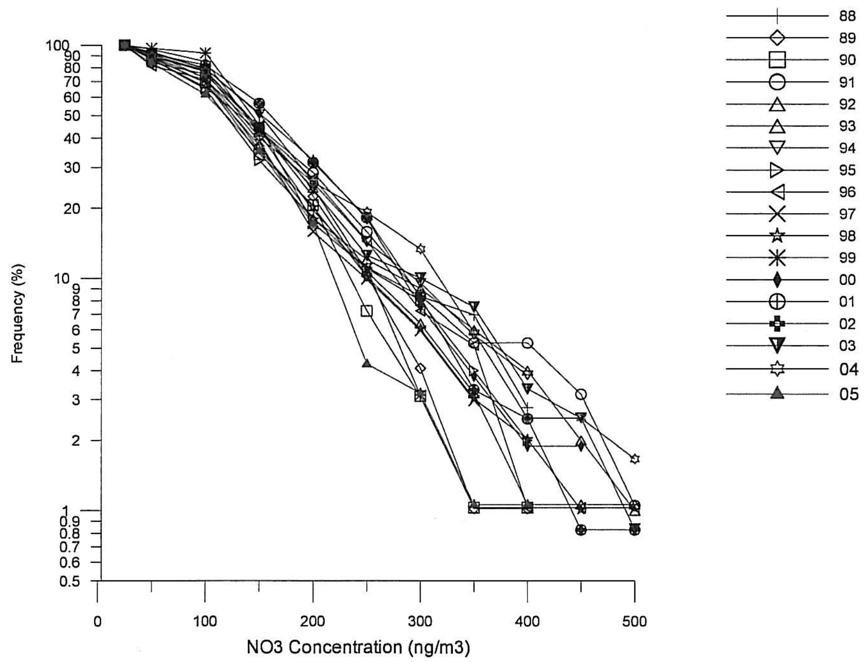

Figure 3. Cumulative Frequency Distribution for Bridger Class I Area NO3 Concentrations 1988-2005

It should be stressed that the 2005 actual emission inventory only includes oil and gas operations from the Pinedale Study Area. Emissions from oil and gas operations beyond the Pinedale Study Area, emissions from non oil and gas industrial sources (trona and power production), mobile sources, residential emissions, etc. are not included in inventory. If these additional emissions were included in the modeling analysis as they are in the monitoring data, modeled NO_3 concentrations would become larger, thus further increasing the amount of model over prediction compared to monitored impacts.

In conclusion, the BP analysis comparison provides conclusive evidence that the CALPUFF model as configured by BLM in the Pinedale analysis is not providing accurate estimates of NO_3 impacts from development and such a serious deficiency must be corrected between draft and final.

Potential Reasons for Model Bias

In a recent paper, Environ conducted a critical review of the chemistry modules in CALPUFF[1]. The MESOPUFF II chemistry module contained in CALPUFF reduces thousands of reactions and hundreds of species into the four equations listed below .

1) $SO_2 \xrightarrow{k_1} SO_4$

2) $NOx \xrightarrow{k_2} HNO_3 + RNO_3$

3) $NOx \xrightarrow{k_3} HNO_3$

4) $HNO_3\,(g) \xleftrightarrow{NH_3} NO_3\,(PM)$

where:

$k_1 = 36 \times R^{0.55} \times [O_3]^{0.71} \times S^{-1.29} + k_{1(aq)}$

$k_{1(aq)} = 3 \times 10^{-8} \times RH^4$ (added to k_1 above during the day)

$k_2 = 1206 \times [O_3]^{1.5} \times S^{-1.41} \times [NOx]^{-0.33}$

$k_3 = 1261 \times [O_3]^{1.45} \times S^{-1.34} \times [NOx]^{-0.12}$

In the MESOPUFF II chemistry module used in CALPUFF, SO_4 formation is described by 4 variables:

1) Solar Radiation;
2) Background Ozone (surface, user provided);
3) Atmospheric Stability; and
4) Relative Humidity (surrogate for aqueous-phase).

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[1] Ralph Morris, Steven Lau and Bonyoung Koo, 2005, Evaluation of the CALPUFF Chemistry Algorithms , Presented at A&WMA 98th Annual Conference and Exhibition June 21-25, 2005 Minneapolis, Minnesota

NO_3 formation is described by 3 variables:

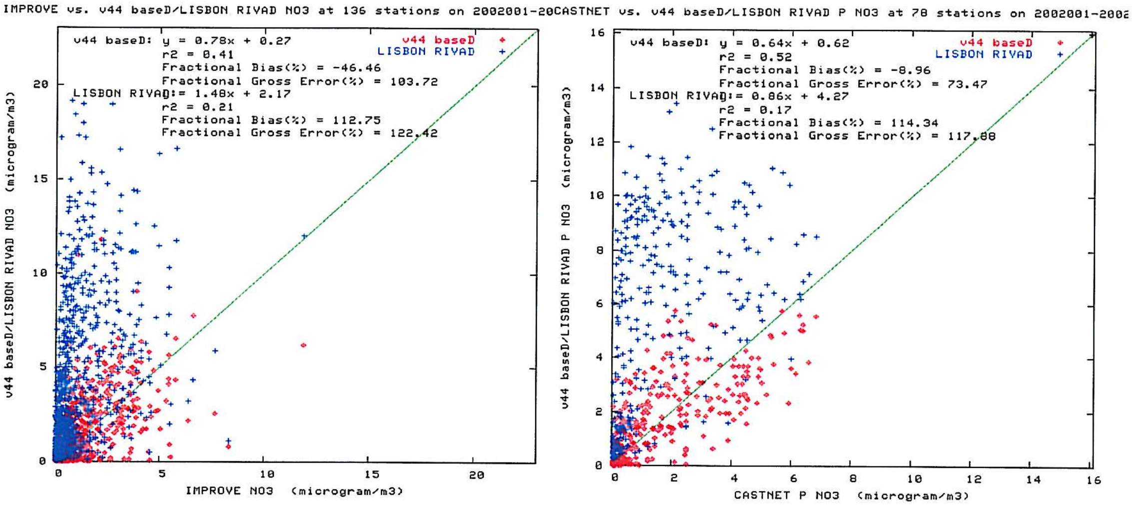
1) Background Ozone;
2) Atmospheric Stability; and
3) Plume NOx Concentration

The Environ paper cites the following theoretical limitations of CALPUFF using the MESOPUFF II chemistry module.

1) Aqueous-Phase SO_4 Formation is inaccurate and is solely based on surface relative humidity (RH). In reality, aqueous-phase SO_4 formation is not at all affected by RH and this assumption is incorrect.
2) The MESOPUFF II transformation rates were developed using temperatures of 86, 68 and 50°F. The lack of temperature effects and 50°F minimum temperature used in development will overstate SO_4 and NO_3 formation under cold conditions.

As part of the Environ paper, comparisons of NO_3 formation using the MESOPUFF II chemistry module in CALPUFF were compared to the IMPROVE and CASTNet monitoring data and Figure 4 present these comparisons. The blue points represent the MESOPUFF II predictions and the red points represent model predictions from CMAQ (a current state of the art photochemical model). As indicated in these figures, the MESOPUFF II chemistry module overstates NO_3 formation where the CMAQ model, using a complete chemical module, correlates better with the observations.

Figure 4. Predicted and Observed NO_3 Levels

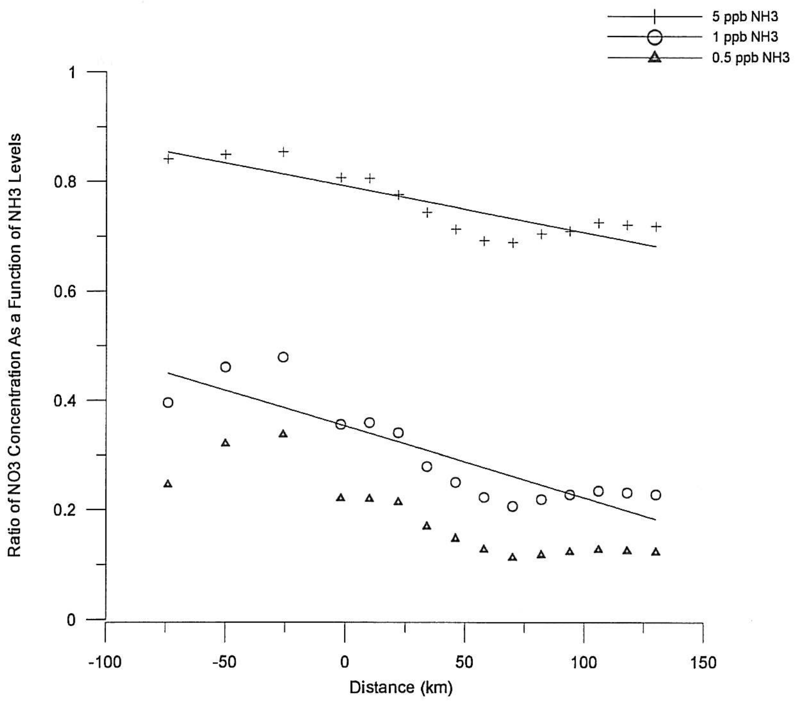


Conclusions Regarding CALPUFF Chemistry

Based on information provided in the Pinedale analysis, it is inappropriate for BLM to issue a Record of Decision (ROD) for development that includes additional mitigation that is predicated on the draft CALPUFF analysis without supporting evidence that the model is accurately predicting concentrations and changes in visibility.

A potential reason that CALPUFF is over predicting observed NO_3 concentrations is the assumed use of the IWAQM default NH_3 concentration of 1 ppb. This assumption is in direct conflict with the modeling analysis that was done for the South West Wyoming Technical Air Forum (SWWYTAF). One major finding of the SWWYTAF modeling verification analysis was that CALPUFF would not replicate observed NO_3 concentrations in the Bridger Class I Area using the IWAQM default NH_3 concentrations. An extensive analysis of air quality measurements in the region concluded that NO_3 formation was limited by NH_3 concentrations. Once this finding was included in the modeling along with boundary conditions, CALPUFF replicated the observed NO_3 concentrations. In the Pinedale EIS analysis, ignoring this finding and using an arbitrary default value adds unnecessary conservatism to the analysis. Figure 5 illustrates the effect on predicted NO_3 concentrations based on background NH_3 concentrations.

Figure 5.



Comparison of NO_3 Predicted Concentrations for Various NH_3 Levels As a Function of Distance

As indicated by this figure, there was approximately a 60 percent difference in predicted NO_3 concentrations by changing the background concentration from 1 ppb to 0.5 ppb. The application of how NH_3 concentrations are used in CALPUFF is very conservative because the model assumes that the NH_3 concentration is uniform between the ground and plume height. In reality, this assumption is not likely to be true and NH_3 concentrations at plume height will be less than those at ground level.

As part of the BP review, an analysis was conducted of estimated mass flux calculations based on a uniform 1 ppb concentration throughout the mixed layer. The CALPUFF modeling was based on a 4 kilometer grid size and a modeling domain of 116 cells by 138 cells. Emission flux estimates were based on assumed wind speeds and mixing heights and were converted into an emission rate based on the size of the modeling domain. Table 4 present regional estimates of NH_3 emissions using this approach.
It was assumed that the wind speed did not vary with height in the screening calculations and as a result this will underestimate emissions. The screening estimates were compared

to NH_3 emission calculations developed by WRAP that indicated that emissions were at a maximum of 1 ton/day in very limited 36 kilometer grid cells and many grid cells had no NH_3 emissions. Based on the mass flux calculations, the assumption of ambient NH_3 concentrations of 1 ppb is inconsistent with the work performed by WRAP and significantly overstates the mass of NH_3 available in the region. Appendix B presents maps of NH_3 emissions prepared by WRAP for the first day of each month of 2002. It should be noted that the maximum modeled visibility impacts occurred in December, however, the 2002 WRAP inventory indicates almost no NH_3 emissions.

Table 4. NH_3 Mass Flux Calculations

Assumptions

Assume 4 km grid square		
Assume 1 ppb of NH3 =	0.695011 ug/m3	mw of NH3 =17
Assume 100 meter mixing height		
Calpuff assumes a uniform NH3 profile		
This means that NH3 concentration will be 1 ppb up to mixed height		

Case 1 - 3 m/s 1000 m mixing height

Upwind face of grid square =	4,000	meters	
height of box =	1,000	meters	Average for day
Vertical area =	4,000,000	m2	
Average wind speed (for a day)	3	m/s	at 10 -meters
Flux	2.09	ug/m2-sec	
mass rate across a grid square	8340132	ug/s	
	8.34	g/s	
	1.05	lbs/hr	
	0.0126	tons /day per grid square	
	15,776	number of grid squares	
	198.9	**Tons/day over entire modeling domain**	

Case 2 - 10 m/s 1000 m mixing height

Upwind face of grid square =	4,000	meters
height of box =	1,000	meters
Vertical area =	4,000,000	m2
Average wind speed (for a day)	10	m/s
Flux	6.95	ug/m2-sec
mass rate across a grid square	27800440	ug/s
	27.80	g/s
	3.50	lbs/hr
	0.0420	tons /day per grid square
	15,776	number of grid squares
	663.1	**Tons/day over entire modeling domain**

Case 3 - 1 m/s 100 m mixing height

Upwind face of grid square =	4,000	meters	
height of box =	100	meters	Average for day
Vertical area =	400,000	m2	
Average wind speed (for a day)	1	m/s	at 10 -meters

Flux	0.70 ug/m2-sec
mass rate across a grid square	278004 ug/s
	0.28 g/s
	0.04 lbs/hr
	0.0004 tons /day per grid square
	15,776 number of grid squares
	6.6 Tons/day over entire modeling domain
WRAP Calculates Approximately	1 ton per day in selected grid squares Approximately 10 percent of the grid squares the rest of the grid cells indicate no NH3 emissions
	49 Tons/day for the modeling domain

Comparison of Mass Flux and WRAP

	Mass Flux	WRAP	Ratio
Case 1	199	49	4.09
Case 2	663	49	13.62
Case 3	6.6	49	0.14

Another issue with the treatment of NH_3 is the manner in which BLM ran CALPUFF. The modeling was separated into 18 individual runs and then the results were added together. This was done to enable source group attribution and because CALPUFF has a limitation of 200 sources. For cases with overlapping plumes as exists in Pinedale, it was assumed that each individual CALPUFF modeling run had 1 ppb of NH_3 available for conversion of SO_2 into SO_4 and NO_2 into NO_3. Thus, as an upper limit the modeling assumed that there was 18 ppb of NH_3 available for conversion. The CALPUFF post processing programs allow combining CALPUFF runs and repartitioning of NO_3 based on NH_3 conditions, however, this option was not used in the BLM analysis.

As indicated in BP's comments regarding model accuracy, it is strongly recommended that BLM take steps to address the issue of large bias (over prediction of actual conditions) of CALPUFF. BP believes that there are several approaches that BLM could take.

1) Abandon CALPUFF and use CMAQ or CAMx for both visibility and ozone.

2) Perform a model evaluation of CALPUFF

3) Develop a scaling approach for CALPUFF

Regardless which option BLM chooses, BLM must correct these deficiencies in the analysis and document.

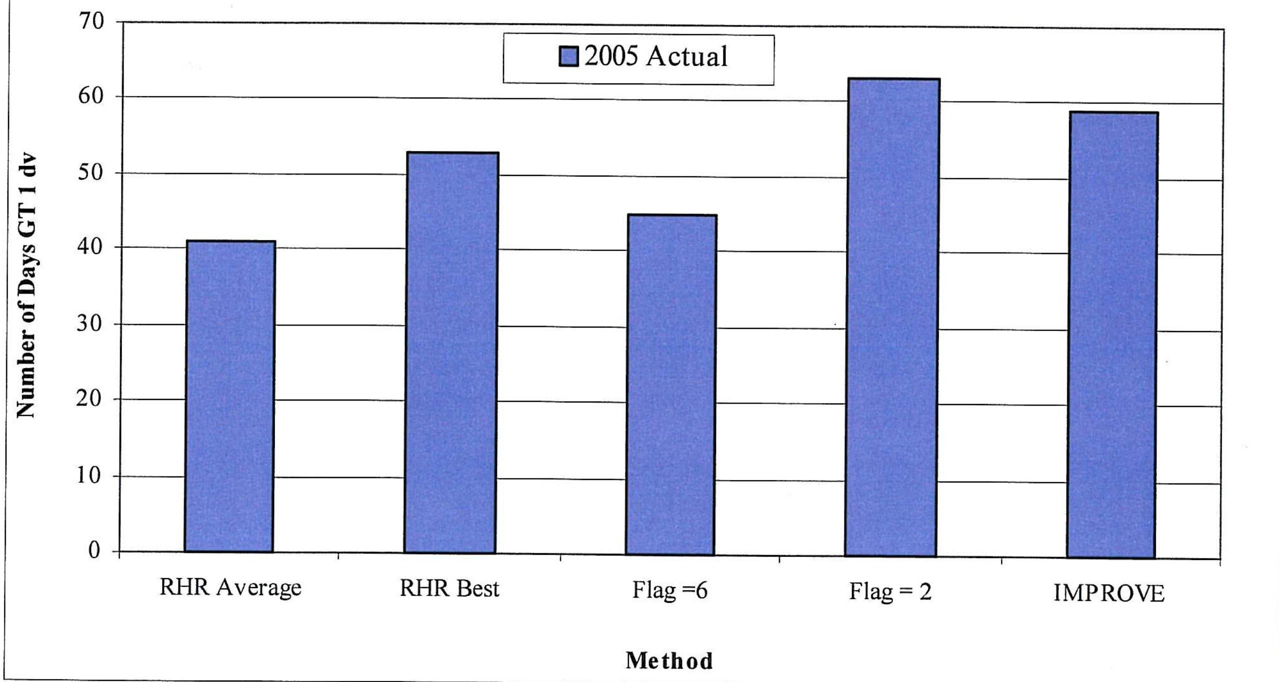
Conversion of Concentrations into Visual Range

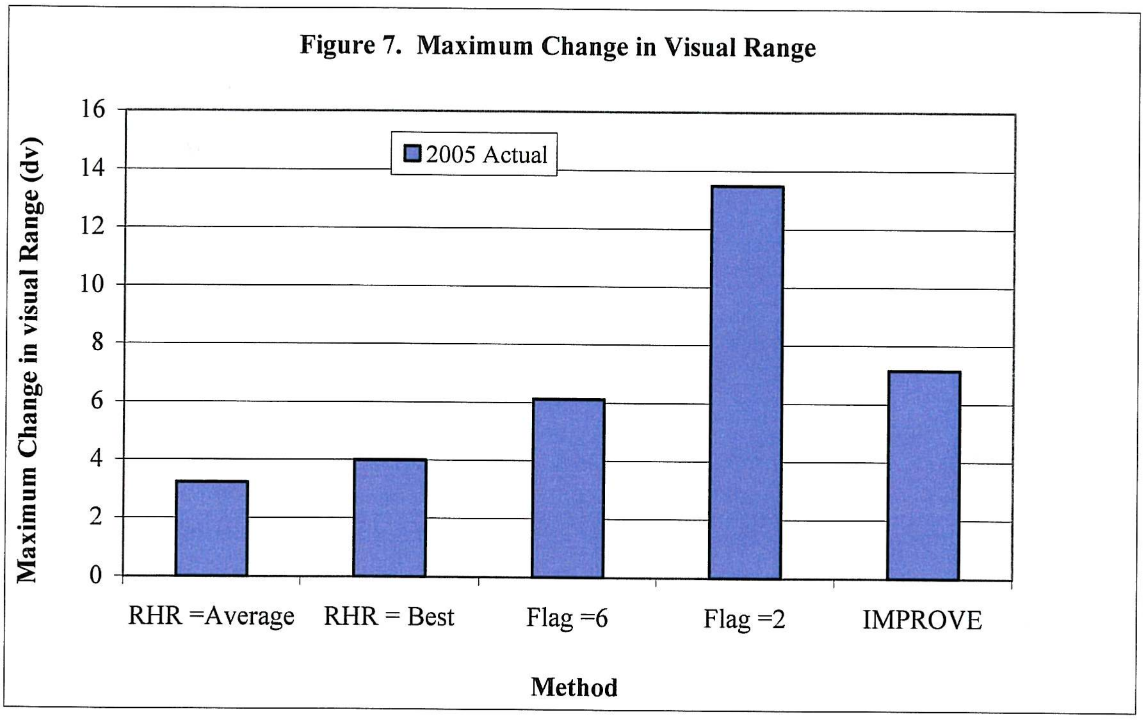
In the TSD, BLM presents five different calculation methods for converting concentrations of fine particulate into changes in visual range. Figures 6 and 7 present the number of days greater than 1 dv and the maximum change in visibility using the five calculation procedures for the 2005 actual case. In these figures the underlying modeling is constant (i.e., the modeled concentration estimates are unchanged). Comparing these methods indicates that there are substantial differences in the perceived change in visibility depending on what calculation method is used. For example, the number of days in excess of 1 dv increases from 40 to 62 in the 2005 actual emission inventory case if the BART calculation procedures are used versus Method 2 that assumes hourly concentration estimates. Similarly, the maximum change in visual range increases from 3 dv (using the RHR and average background concentrations) to almost 14 dv (using Method 2). This perceived change in visibility is simply a function of different calculation methods. It is important to keep in mind that this information is for 2005 actual conditions and such projections are inconsistent with the monitoring data.

It is recommended that BLM adopt the RHR using average conditions. There is a technical basis for this selection as all of the other calculation procedures assume very clean background conditions (IMPROVE cleanest 20% days or FLAG default) for every day of the year, an unrealistic assumption. Maximum visibility impacts are based on the maximum modeling impacts that occur under worst case meteorological impacts and assuming that they coincide with the days having the best visual range is counter intuitive. In addition, the RHR using average air quality is consistent with the methodology that is being used by EPA and the States to determine if a source is exempt from performing a BART analysis. The other suggested calculation procedures have no regulatory basis.

It is also recommended that BLM adopt the revised IMPROVE calculation procedures that were established in 2006.

Figure 6. Change in Visual Range by Methodology





The Interpretation of What Constitutes a "Just Noticeable Change" in Visibility

BP has previously submitted extensive comments regarding the application of a Just Noticeable Change (JNC) of 1 dv. BLM has not address these concerns in the past; however, it is important to point out the limitations in the assumed JNC of 1 dv threshold. While BLM and Forest Service have established a level of concern regarding source impacts and visibility, it is important for the public and decision makers to understand the basis for estimating the just noticeable change (JNC) in visual range as specified by EPA and used in the analysis. The following presents a discussion of those procedures. One basis of the JNC is the National Acidic Precipitation Program (NAPAP) Report. A review of the information provided in the NAPAP Report indicates that the JNC was based on the Quadratic Detection Model proposed by Carlson and Cohen that was used to predict thresholds of perceived image sharpness in video type image displays[2]. While the theory used for defining a JNC threshold in a video monitor may be applicable to air quality visibility issues, neither EPA nor the NAPAP Report have provided any

[2] Carlson and Cohen. 1978. Image Descriptors for Displays: Visibility of Displayed Information. RCA Laboratories, Princeton, NJ.

supporting evidence that the JNC threshold in video monitors is in any way applicable to determining changes in visual ranges in the atmosphere over long sight paths.

Universal Applicability of JNC Over Long Sight Paths

The NAPAP reference raises several important questions regarding the JNC threshold over long sight paths. First, there is no clear definition of what the statement "a change in extinction coefficient of approximately 5% will evoke a just noticeable change **in most landscapes**" means. Second, it is also unclear how universally applicable this threshold could be over a large range of sight paths. Figure 8 presents a plot of the JNC threshold as a function of sight path and indicates that the JNC threshold is dependant on the sight path[3]. This suggests that the establishment of a human perceivable JNC threshold may be dependant on the longest sight path within a Class I Area and that the establishment of a single JNC threshold might not be appropriate and therefore contrary to what EPA has proposed.

Deciview Visibility Unit of Measure

An additional reference provided regarding a human JNC threshold is an Atmospheric Environment paper written by Pitchford and Malm[4]. This paper outlines the concept of the deciview visibility unit of measure in which the authors conclude, based on what

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[3] National Acid Precipitation Assessment Program (NAPAP). Acid Deposition: State of the Science and Technology Report 24, Visibility: Existing and Historical Conditions-Causes and Effects, Washington, DC, 1991. See Appendix D. p.24-D2.

[4] Pitchford M. L. and W. C. Malm, 1994 "Development and Applications of a Standard Visual Index" Atmospheric Environment Vol. 28, No. 5 pp. 1049-1054

appears to be a sensitivity analysis, "From this it seems **reasonable to**

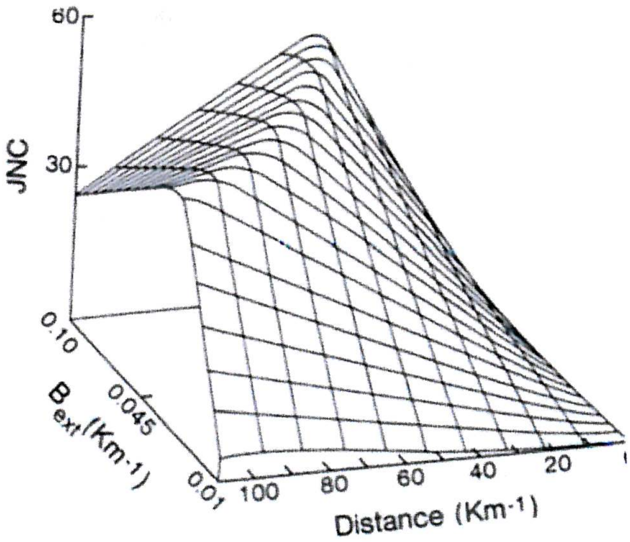

Figure 8. Just Noticeable Change Surface Plotted as a Function of Observer Distance and Atmospheric Extinction.[5]

presume that a fractional change in extinction coefficient between 5 and 20 % would produce a JNC in a scene"[6]. The use of what appears to be a **presumptive** sensitivity analysis to develop a JNC threshold is not appropriate. The authors also conclude "a 1 to 2 dv change corresponds to a small visibility perceptible change in a scene appearance **where the assumptions used in developing the deciview scale are met.**"[7] This would translate to a change of 10 to 20 percent in extinction. Because a 1 to 2 deciview change is perceivable only if the assumptions used to develop the deciview scale are met, it is important to review the assumptions that were made in the development of the deciview

[5] National Acid Precipitation Assessment Program (NAPAP). Acid Deposition: State of the Science and Technology Report 24, Visibility: Existing and Historical Conditions-Causes and Effects, Washington, DC, 1991.
[6] Pitchford M. L. and W. C. Malm, 1994 "Development and Applications of a Standard Visual Index" Atmospheric Environment Vol. 28, No. 5 pp. 1049-1054
[7] Pitchford M. L. and W. C. Malm, 1994 "Development and Applications of a Standard Visual Index" Atmospheric Environment Vol. 28, No. 5 pp. 1049-1054

scale because they define the limitations on universal applicability of this visibility unit of measure. Other deciview assumptions are:

1) Contrast is a good indicator of visibility. The apparent contrast of an element of a scene can be used to estimate whether the element can be perceived and, when it can be perceived, the apparent contrast can also be used to evaluate the visual quality of its appearance.
2) The magnitude of the change in apparent contrast of a distant terrain feature against the horizontal sky required for a JNC is proportional to the apparent contrast of the terrain feature.
3) The apparent contrast of a distant terrain feature against the horizontal sky is given by the following equation:

$$C=C_o \exp(-r\, B_{ext})$$

Where: C is the apparent contrast

C_o is the initial contrast

B_{ext} is the average extinction coefficient for the sight path

r is the distance to a distant terrain feature

The first assumption regarding contrast being an indicator of visibility is generally accepted.

Inherent in the second assumption is that, for a change to be noticeable, the magnitude of the change is proportional to the change in contrast as stated in the following equation.

$$\text{delta } C_{JNC} = L\, C$$

Where: L is a constant that depends on spatial frequency but not contrast

The work of Carlson and Cohen has shown that this equation is not generally considered valid, but may provide a reasonable approximation in viewing environments such as a view of a terrain feature against the horizontal sky[8]. As such, this assumption could be considered in development of a JNC threshold.

The third assumption is valid if the horizontal sky radiance has the same value at each end of the sight path. Further, it can be regarded as a restriction that the use of the deciview index or extinction applies to terrain features against the sky. In general, the use of the deciview index only applies to the special case where the sight path is equal to the visual range. This assumption is also applicable to the manner in which the 5 percent change in extinction was defined as a JNC threshold. This is a significant over simplification of the proposed JNC threshold.

In a review of the aforementioned Pitchford and Malm deciview scale, Richards indicated, "For example, more than a 40 % change (more than 4 – dv change) in regional haze is required for the change to be perceptible in sight paths shorter than 20 % of the visual range."[9] Richards also states that in some cases a 5 percent change in contrast can be perceivable but it is commonly assumed that features with only a 2 percent change in contrast can be perceived. Using this information, Richards shows that the Pitchford and Malm equations can be rewritten as follows:

For a 2 percent case

$$\text{delta } b_{JNC} = 0.4 / r$$

and a 5 percent case

$$\text{delta } b_{JNC} = 0.32 / r$$

These equations apply to sight paths of any length less than or equal to the visual range and give the value for delta b_{JNC} equal to those calculated by the Pitchford and Malm work when the sight path is equal to the visual range.

Based on the importance of the inclusion of sight path in the determination of the JNC, it seems imperative that EPA incorporates this approach into the JNC threshold

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[8] Carlson, C.R. and R.W. Cohen 1978 "Visibility of displayed information. Image descriptors for displays" RCA Laboratories, Princeton N.J.

[9] Richards, L.W., 1999,"Use of the Deciview Haze Index as an Indicator for Regional Haze", AWMA

determination. This would require that the JNC threshold be site specific for each Class I Area and that individual states would be required to develop their own JNC threshold for each Class I Area. Incorporation of this approach would ensure that the JNC threshold would be based on the "best science".

Practical Perspective of the Deciview Assumptions

It is important to place the assumptions used by Pitchford and Malm into practical perspective. Figure 9 presents a comparison of the longest lines that can be drawn within 35 Class I Areas as well as the estimated lengths of the longest visual range sight paths within these areas[10]. The visual ranges were calculated from the average light extinction coefficient for the 20 percent of the days that were the least impaired (clean) as well as the 20 percent of the days that were the most impaired (hazy). A point on a line indicates the percentage of the parks that have a ratio equal to or smaller than the value at that point. Most ratios are less than 1 and therefore sight paths are typically shorter than the visual range and contrary to the assumptions used in the development of the deciview index. This indicates that for a vast number of Class I Areas, the basic assumption of the deciview calculation has not been met. Thus, assuming that the sight path is equal to the visual range simply adds a layer of unnecessary additional conservatism to the calculation.

[10] Richards, L.W., 1999,"Use of the Deciview Haze Index as an Indicator for Regional Haze", AWMA

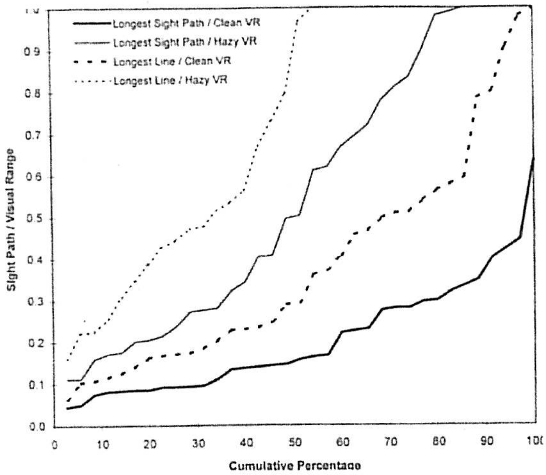

Figure 9. Comparison of Lengths of the Longest Lines for 35 National Parks and the Estimated Sight Path Within These Parks[11]

Also, FLAG (a guideline, not a regulation) considers a 0.5 dv change in visibility significant for a single source and 1.0 dv significant for a cumulative analysis. Based on the above information, the public and the decision makers should not consider the Forest Service LOC of 0.5 dv as a decision point for this analysis. Further, based on the information presented in these comments, it is important to keep in mind the conservative nature of a 1.0 dv threshold.

Comments of Ozone Analysis

BP believes that current WDEQ air quality permitting practices, air quality monitoring, the composition of VOC emissions from oil and gas operations and realistic VOC emission growth projections will ensure that the ozone air quality standard in Wyoming will not be exceeded. Ambient air monitoring is being used as used as the tool to demonstrate compliance with the standard and evaluate if the current control levels are adequate. In addition, Wyoming DEQ has been conducting a major field/modeling analysis to understand winter ozone formation in southwest Wyoming. It is believed that

[11] Richards, L.W., 1999,"Use of the Deciview Haze Index as an Indicator for Regional Haze", AWMA

the Supplemental Ozone modeling analysis prepared by BLM does not add any substantial new information regarding ozone formation in southwest Wyoming. Until the results of the Wyoming DEQ analysis are completed and ozone formation during the winter is understood, conducting additional modeling analyses will not provide any new meaningful information.

Level of Emission Control in Wyoming

Important factors in analyzing the growth of emissions from new wells in the Pinedale Field are the stringent Wyoming DEQ VOC regulations. All new wells must comply with these regulations and the result is a substantial reduction in VOC emissions. These regulations are summarized in the following:

Control Requirements for Single Well Facilities

Flashing Emissions

1) Emission controls meeting BACT requirements are required for projected average annual VOC flashing emissions equal to or greater than 30 tons per year. In this context, WDEQ requires a control efficiency of 98 percent.

2) Controls required for flashing emissions must be installed within 90-days of the First Date of Production

3) Controls for flashing emissions when installed will remain operational for at least one year after the date of installation. After this time, the controls may be removed provided the previous 30-day, uncontrolled, annualized VOC emission rate is less than 20 tons per year.

Dehydration Emissions

If projected potential annual VOC or total HAP emissions from dehydration units are equal to or greater than 15 tons per year VOCs or 5 tons per year total HAPs, controls must be installed within 90 days of the First Date of Production.

Reciprocating Internal Combustion Engines (RICE)

As part of the permitting process, BACT is required to be installed on all new natural gas fired engines. This regulatory requirement mandates the installation of emission controls for NOx and HAPs (HAP controls will result in a reduction of VOC emissions).

CALGRID Modeling Analysis

The BP review of the CALGRID ozone modeling is summarized in Table 1. This table presents a ratio of 2005 emissions and the WRAP 2018 oil and gas emissions that were used in the CALGRID modeling. As indicated in this table, NOx emissions in this analysis were 8 times the 2005 emission level and VOC emissions were 38 times 2005 levels. The table also presents the ratio of predicted to observed ozone levels for the highest and 4th highest modeled and monitored values. As indicated in the table, the using the 2018 WRAP emissions in the modeling is over predicting the highest monitored values by approximately 40 percent. For the 4th highest concentrations CALGRID is replicating the monitored values, however, emissions used in the modeling are substantially higher than actually occurred.

Table 1. Summary of BLM Ozone modeling Results

	Emission Summary			
	NOx	CO	VOCs	SO2
2005 emissions (t/yr)	3,988	3,174	2,731	231
WRAP 2018 oil and gas (t/yr)	32,686	2,469	103,709	8
ratio wrap/2005	8.20	0.78	37.97	0.03

Predicted		Monitored		
Max	Location of Model Prediction	Max	Monitor	Ratio of monitoring to modeling
97	Yellowstone	97	Yellowstone	1.00
77	Yellowstone	77	Yellowstone	1.00
118	Northeastern Lincoln County	82	Daniel	1.44
114	Western Fremont County	81	Bolder	1.41
105	Western Sublette County	98	Jonah	1.07

Predicted		Monitored		
4 th high	Location of Model Prediction	4 th high	Monitor	Ratio of monitoring to modeling
68	Yellowstone	68	Yellowstone	1.00
59	Yellowstone	59	Yellowstone	1.00
69	Northeastern Lincoln County	74	Daniel	0.93
69	Western Fremont County	72	bolder	0.96
76	Western Sublette County	70	Jonah	1.09

NO2 Increment

The Draft PAPA SEIS (DSEIS) articulates modeled near field NO_2 concentrations which exceed the PSD increment of 25 ug/m^3 when modeling an actual 2005 PAPA NOx emission inventory of 3512 tons/year. The direct project model predicted impact concentration in the document is shown in Table 1.8 of Volume 2 Appendix I as 31.6 ug/m^3 NO_2 compared against an allowable PSD increment consumption of 25 ug/m^3. Review of the modeling files indicate that this predicted concentration is likely attributable to sources at the Pinedale Compressor Station. The maximum predicted receptor is located within approximately 200 meters of 9 compressor engines. When this source was permitted with Wyoming DEQ Air Quality Division part of the permitting process would have been to perform a modeling study that demonstrated that this facility is in compliance with air quality standards including PSD Class II increment for NO2. Wyoming DEQ could not have issued a permit for construction if that analysis indicated an exceedance of the NO2 PSD increment. This is in contrast to the BLM analysis that indicates an exceedance of the increment.

This is in stark contrast to the regulatory PSD increment demonstration conducted by the Wyoming DEQ where a modeled inventory of 10,978 tons of increment consuming NOx (of which 2,900 was located directly in the Jonah/Pinedale complex) yielded a maximum near field predicted concentration of 11.5 ug/m^3 NO_2 – which is compliant with the PSD increment for NO_2. Given the likely installation date of the Pinedale Station compressors, it is believed that these sources were included in the Wyoming DEQ analysis. The excerpts from this report directly below illustrate the inventory modeled and the predicted increment consumption.

Table SR-1. Annual NO_x emissions (tons) for sources in Sublette County and the Bridger and Naughton power plants.

	Source Category	Current	Baseline
	Jonah-Pinedale Development Area oil & gas production	2,908	9
	Other Sublette Co. oil & gas production	1,383	445
	Point Sources	1,602	910
	On-Road vehicles	515[1]	766
Other Area Sources	Agricultural Equipment	161[2]	182
	Recreational Equipment	58[1]	55
	Other Area Sources	59[1]	86
Sublette Co. Total:		6,686	2,453
	Bridger Power Plant	34,321	28,115
	Naughton Power Plant	13,240	12,701
Power Plant Total:		47,561	40,816
Grand Total:		54,247	43,269

	Increment Consumed (µg/m^3)	Maximum PSD Allowance (µg/m^3)
Class I	0.14	2.5
Class II	11.50	25

Based on the Wyoming DEQ increment demonstration conducted in 2005 for an emissions year of 2004, the Draft SEIS predicted direct modeled concentrations of NO_2 for the 2005 baseline year are unreasonably high and not a valid representation of potential impact.

This gross over-prediction in the Draft SEIS extends through all of the alternatives modeled and yields direct model predicted impacts exceeding the PSD increment for NO_2 in all cases except the "Alternative C – 80% mitigation" case.

The Draft SEIS and Air Quality Technical Support Documents do not contain enough detail to ascertain exactly how the modeling of NOx was conducted, where the sources were located, and where the maximum predicted impacts occurred or even what the resolution of the receptor grid was in the near field. Also, modeled stack heights for drilling rigs are not consistent between the nearfield and mid and far field analyses. Due to this lack of detail, in-depth analysis and comments are not possible.

To correct the overstated impacts and allow full evaluation of the modeling, the NOx modeling must be refined through a more complete source description, facility boundaries and perhaps using an hourly ozone limiting analysis. The results of this refined analysis need to be fully described, and the document amended.

The document is also deficient in its discussion of the modeled NO_2 concentrations that are greater than the PSD allowable of 25 ug/m^3. It does include repeated qualifications that the modeling is not a regulatory PSD increment comparison and is intended to "evaluate a threshold of concern for potential impacts" (Air Quality Impact Analysis Technical Support Document (AQTSD), Vol. 1, Paragraph 3.4 and elsewhere throughout the document) based on some criteria not explained. BP agrees that BLM cannot regulate PSD increment, but it must disclose such projected impacts. As BLM notes in Chapter 4 of Vol. 1 of the Supplemental EIS, BLM cannot authorize an action that is not in compliance with applicable air quality laws and regulations. The only statement that partially addresses this dilemma is one in paragraph 3.4.3 of Vol. 1 of the AQTSD that simply states *"In addition, because the emissions from drilling rigs are temporary and do not consume PSD increment, and as a result, are excluded from increment consumption comparison."* If the NO_2 modeling analysis is not intended as an increment consumption comparison, rigs do not consume increment, and the BLM's authority for regulation of air quality is simply assuring that they do not approve an action that is in conflict with applicable air quality laws and regulations it is unclear what purpose BLM intends for the modeling and discussion of NO_2 increment in the document. As noted above, the Wyoming DEQ AQD recently completed a regulatory increment comparison which, as the agency with primary jurisdiction for air quality management in the State of Wyoming, does have the weight of regulatory applicability and certainty.

The BLM's intent in conducting the NO_2 PSD increment comparison in the document should be clarified along with what the BLM's authority for using this as a "threshold of concern" is, what criteria BLM intends to use to evaluate the modeled impacts against this "threshold of concern", and what actions, if any, BLM believes are within their authority to take based on the modeling analysis for NO_2 increment.

The fact that the Wyoming DEQ AQD included rig emissions in its 2005 regulatory PSD increment comparison for NO_2 also calls into question the agreement of the cooperating agencies with the statement that rig emissions do not consume increment. Although we believe BLM is correct, this needs to be more fully described in the document.

PM_{10}

The annual ambient air quality standard for PM_{10} was rescinded in December of 2006 and reference to it should be removed from the document.

The DSEIS also articulates modeled PM_{10} concentrations which are above both the 24 hour and annual PSD allowable increments. Similar to the NO_2 increment discussion above, BLM's intent in conducting the PM_{10} PSD increment comparison in the document should be clarified along with what the BLM's authority for using this as a "threshold of concern" is, what criteria BLM intends to use to evaluate the modeled impacts against this "threshold of concern", and what actions, if any, BLM believes are within their authority to take based on the modeling analysis for PM_{10} increment. BLM should also include a discussion of whether the source (s) culpable for the modeled impact are increment consuming or not and why.

The document does not contain enough information to ascertain what source (s) is culpable for the modeled PM_{10} impacts nor where these impacts are occurring. This lack of information should be corrected to enable a robust analysis and review of the PM_{10} model analysis described in the DSEIS.

Completion Operations

The discussion of "green completions" in Volume 2, Appendix C, Page C-5 should be modified to note that completion operations proposed under this proposal would continue to comply with the Wyoming DEQ AQD flaring permits for the Pinedale Anticline operations. Any further discussion of recovery percentages, equipment to be utilized, and techniques to be utilized should be removed. Portions of the draft discussion are not necessarily in conformance with the specific permit requirements and language. Modification of the Wyoming DEQ AQD flaring permits in this action are beyond the scope of BLM's authority.

Item 33, on page E-7 of Volume 2 Appendix E, should be modified to read that "Operators would continue to comply with the provisions and stipulations contained in the Pinedale Anticline "Green Completions" flaring permits issued by the Wyoming DEQ AQD." Establishing a redundant requirement under this action that would require "case-by-case" proof that flareless completions would be unsafe is a modification of the existing flaring permits which is beyond BLM's authority.

BP America's Comments:

Draft Supplemental Environmental Impact Statement, Pinedale Anticline Oil and Gas Exploration and Development Project

General

Item: Concentrated Development Area Concept
Comment: The DSEIS focuses on the "Core Area", and the "Concentrated Development Areas" (CDAs). The BP leases are outside of the Core Area (in both alternatives), and there is little to no description on development outside of the Core Area. It is unclear from the DSEIS how operations are supposed to proceed outside of the Core Area. That is, do the operational parameters described in the DSEIS for development apply to areas outside the Core Area, or are those areas managed with the 2000 ROD?

Item: Staged Development
Comment: BP is very concerned about the potential precedent established by BLM's use of staged or phased development as expressed in the BLM Preferred Alternative (Alternative C). Staged development, which allows development in one area of the field while prohibiting development in another area may be applicable to the PAPA based upon the land configuration and ownership pattern. However, the approach will not be appropriate in most other natural gas development projects. The main reason is the fact that lease ownership in other natural gas fields may not allow similar management techniques. Lease ownership may be more fragmented, such as in checkerboard areas, that are not conducive to staged development. In certain circumstances, staged development could actually deny operators the right to develop their leasehold in a timely manner which would be a violation of their lease rights and obligations, or allow certain operators to unfairly benefit from, or bear the burden of, changes in commodity prices. Staged development could also create an imbalance of impacts on other public land users where impacts of development would be concentrated in one particular geographic area. Therefore, the application of staged or phased development in this particular case should not be interpreted as being appropriate to other natural gas development NEPA analyses.

Executive Summary

Item: page V. **Offsite Mitigation**
Comment: The Executive Summary under Alternative B states "The Operators have offered 3:1 offsite mitigation for wildlife, if necessary." Appendix C states , "the Proponents have agreed to a 3:1 acre off-site mitigation ratio in the event that off-site mitigation is required to compensate for loss of on-site habitat (i.e., for every acre of

long-term on-site habitat disturbed by the project, Proponents will improve three acres off-site habitat)." Also, in Appendix C (page C-34) The Proponents commit to developing a comprehensive off-site mitigation plan within one year of SEIS ROD release.

This mitigation measure seems vague. How was a 3:1 ratio arrived at as fair compensation? Who determines the "if necessary" and what criteria will be used for this decision. If offsite mitigation is "necessary", where, when and to what extent will offsite improvements will occur? What type of habitat would qualify for the 3:1 mitigation requirement? Will offsite mitigation be applicable and/or optional to the flank areas outside the Core and CDA's? These are all important questions that must be answered in order to proceed with an effective offsite mitigation program.

Chapter 2 Public Participation, Existing Development and Alternatives

Item: Section 2.5.2.14, **Alternatives**
Comment: This section and subsequent sections (2.5 - 2.14) present the various alternatives to the DEIS. While BLM has provided a range of alternatives as required by NEPA, BP supports the "Preferred Alternative" Alternative C, as revised in a separate joint operator communication to BLM commenting upon the DSEIS, and suggesting an expansion of DA-5. This alternative was developed with a commitment to various mitigation measures including onsite and offsite compensatory mitigation. We believe that with the mitigation, monitoring and other revisions, being proposed by the companies that this alternative is viable and should be selected.

Item: page 2-29, Section 2.4.2.4, **Alternative C Reclamation**
Comment: Alternative C – BLM has developed Performance-Based Objectives, which would apply to Alternative C (Appendix E). For each objective, the performance, or outcome, is the basis for judging the effectiveness of whatever measure is actually implemented. Some developed performance-based objectives may not be obtainable due to circumstances beyond operators control and the Plan of Development within each development area needs to take such circumstances into consideration.

Performance Based Objectives states that "On existing well pads that would not be fully developed within the upcoming annual cycle, all bare ground would have at least a 75 percent protective cover." .. ."During the period when an existing well pad is not being fully developed, the well pad would be vegetated prior to the first winter after the ROD to achieve at least 50 percent vegetative cover of desirable herbaceous species by the following spring."... and "Once a well pad has been fully developed, full site restoration and reclamation would begin as soon as the ground is not frozen and would be completed before the onset of winter."

These conditions may be impossible to achieve within the referenced time-lines based on site specific situations (i.e. weather conditions, soil composition, animal foraging etc.).

Chapter 4 Environmental Consequences

Item: Wildlife Impacts
Comment: The PAPA SDEIS appears to misinterpret the potential impacts to pronghorn antelope from oil and gas development in the vicinity of Jonah Field. In particular, on page 4-130 of the PAPA SDEIS, the BLM cites the Berger (2006) study that antelope do not utilize habitat within the Jonah Field. However, the DEIS does not acknowledge the more important conclusions from the Berger study; especially a lack of significant differences noted among pronghorn populations exposed to oil and gas development near PAPA and Jonah Field for such important viability factors as overall survivability, body mass, stress hormones (glucocorticosteroids), disease antibodies, and vitamins and minerals. *See* Berger, pgs. 16, 19, 22, 31, 35, 45. Further, the fact that the pronghorn populations studied by Berger did not utilize habitat within the Jonah Field during the study period does not demonstrate that pronghorn will generally avoid the Jonah Field. The studied populations may simply not have ever utilized the relatively mediocre habitat within Jonah Field. *See* JIDP FEIS, pg. 3-55 (indicating Jonah Field does not contain any crucial winter range or crucial winter/yearlong range for antelope).
The PAPA SDEIS also fails to note the significant increase in antelope populations in the vicinity of Jonah Field and PAPA in recent years. In 2005, antelope population in the Northern Sublette Herd Unit and the Pronghorn Sublette Herd Unit were at all-time highs of 27,537 and 47,930, respectively. *See* PAPA SDEIS, pg. 3-107. These levels are dramatically higher than those seen in the late 1990's prior to major oil and gas operations in Jonah Field and PAPA. According to the BLM's analysis in the JIDP EIS, antelope populations in the Northern Sublette Herd Unit were estimated at 19,900 in 1994 and 17,900 in 1998, compared to the reported 27,537 in 2005. *See* JIDP FEIS, pg. 3-54; PAPA SDEIS, pg. 3-107. Therefore, it appears antelope populations in the vicinity of Jonah Field are not only stable, but improving. With the approval of habitat improvement projects such as those sponsored by the Jonah Interagency Office ("JIO") last year, population trends will likely continue to improve. The BLM should revise the information in the SDEIS regarding existing antelope population and impacts from oil and gas development.

The BLM also places a reliance on the Holloran (2005) study regarding the potential impacts of natural gas development activities on sage-grouse. However, in discussing the Holloran study, and any potential conclusions derived therefrom, the BLM should specifically disclose and acknowledge the fact that the agency purposefully waived the seasonal and timing stipulations normally associated with sage-grouse leks and specifically allowed oil and gas development activities near an active lek during the strutting season in order to assess the potential impacts. The conclusion in the Holloran study that existing stipulations are not adequate cannot be supported considering the manner in which the leks were allowed to be impacted. Further, prior to the release of the Holloran study, the Wyoming State BLM issued new policies to provide additional measures to protect sage-grouse. The new measures include new surface use restrictions, timing limitations, and additional surveys prior to operations in sage-grouse habitat. *See* Wyoming Instruction Memorandum 2004-057 (August 16, 2004). These mitigation measures were eventually incorporated into the Pinedale Resource Management Plan ("RMP") through a maintenance action. Therefore, it is important to understand the complete context in which Mr. Holloran's study was conducted and take into account recent BLM policies regarding actions to protect sage grouse.

The PAPA SDEIS also fails to include a discussion about the significant increase in sage-grouse populations since 2003. According to the information presented in Figure 3.22-2, it appears sage-grouse populations on the Mesa and in the vicinity of PAPA and Jonah Field are at all time highs. The dramatic increase in the sage-grouse population since 2003, a time period that has included significant increases in oil and gas development in Jonah Field and PAPA, may indicate that oil and gas development is not adversely impacting sage-grouse to the extent previously disclosed. In fact, this data suggests that BLM's mitigation, including seasonal timing stipulations, are effective and that recent declines may not be linked to oil and gas development. The BLM should revise section 3.22.1.2 of the PAPA SDEIS to more accurately reflect the current trends and protections available for sage-grouse in the Pinedale Resource Area.

Item: Section 4.4.3.1, Page 4-34, **Road funds**
Comment: "Reduced federal funding would limit highway maintenance opportunities on roads used to access the PAPA. Increased traffic in the PAPA would accelerate deterioration of area roads beyond the maintenance capabilities of the responsible agency".

This statement does not account for partial funding from county taxes generated from Operators.

Item: Section 4.64, Page 4-48, **Recreation Impacts**
Comment: "The cumulative impact to public recreation areas in the PAPA (Table 4.6-2) is based solely on estimates of surface disturbance within the areas by well-field development projected by each alternative."

It is not clear how Recreation Resources related to OHV-orientated recreational areas limited to existing roads and trails would be directly affected by surface area disturbance. It would be more appropriate to analyze closure and disturbance to the existing roads and trails combined with any well-field related restrictions on recreational travel.

Item: Section 4.7.3.1, Page 4-51, **Alternative Impacts, VRMs**
Comment: Below is an excerpt from the BP Amoco letter (Kirk Steinle) to BLM related to comment on the DEIS dated Feb 4, 2000. This comment still applies.

"The discussion relative to the VRM III classification and the interpretation of its management objective must be tempered with the fact that in some circumstances it will be impossible to "screen activities and facilities so they do not dominate the view of the casual observer." This possibility exists in the event some level of development occurs on the south of the PAPA . BP Amoco clearly understands the concerns that the BLM and public have relative to this VRM issue. I also believe the BLM understands that implementation of the management objective for this VRM III area, as defined above, could be problematic in a number of cases as it relates to oil and gas exploration and development in this area. I also question the definition interpretation of the VRM III management objective. What is the basis for that definition? BP Amoco would like the BLM to consider in its management of this issue an obvious recognition that the east side of Hwy. 191 (Wind River Mountain viewshed) is likely more sensitive than the west side of Hwy. 191 and that the implementation of this management objective interpretation, if carried forward, be balanced considering this fact."

Item: Section 4.10.2, Page 4-75, **Alternative Impact Mitigation, Noise**
Comment: Below is an excerpt from the BP Amoco letter (Kirk Steinle) to BLM related to comment on the DEIS dated Feb 4, 2000. This comment still applies.

"...The document merely comments that the 10dBA above background proposed limit is likely acceptable. If there is no scientific basis for this proposed mitigation and therefore the proposed mitigation is arbitrary and capricious, the BLM decision maker should not consider this proposal for inclusion in this EIS/ROD."

The SEIS defines significant noise impact as greater than 49 dBA (10dBA above background).

Item: Section 4.16.2, Page 4-99, **Vegetation Resources**
Comment: "sagebrush, the predominant shrub within the PAPA, may take 10 to 20 years to become reestablished"

This should be considered in the performance based objectives for reclamation.

Item: Section 4.19.3, Page 4-114, **Threatened and Endangered Species**
Comment: The FWS recommended the following spatial and timing constraints: avoid activities within 1 mile of active bald eagle nests from courtship (February 1) through fledging (August 15); avoid activities within 1 mile of roosts used during winter, November 1 through April 1; and strive to conserve potential nesting, roosting, and foraging habitats of mature and old growth trees, particularly within 0.5 mile of water.

This only leaves September and October for any activities within 1 mile of bald eagles.

Proponents proposed:
1. Avoid potentially disruptive activities or permanent aboveground structures in the bald eagles' direct flight path between their nest and roost sites and important foraging areas."

Recommend this be reworded to add, "...to the extent practicable...".

Item: Section 4.20.2, Page 4-127, **Wildlife Impacts**
Comment: "Evidence collected since the PAPA DEIS has shown that the functions of some wildlife habitats, those classified as "vital" or "high value" by WGFD, has declined as wellfield developments have progressed. Such evidence has been based on species' use of habitats before and after development. In other cases, species' use of habitats proximate to disturbance has declined whereas use of habitats farther away from disturbance has not."

Consideration should be given to emigration. Species which have emigrated may return after restoration and reclamation.

Item: Section 4.20.3.1, Page 4-128, **Wildlife Impacts**
Comment: "Another measure of fragmentation is the amount of edge created by wellfield development. In the context of habitat fragmentation, edge is the portion of habitat (or ecosystem on a larger scale) 'near its perimeter, where influences of the surroundings prevent development of interior environmental conditions'" (Forman, 1995).

Little research on edge effects has occurred regarding oil and gas development in the western United States. Studies that have occurred in the western US focused on roads - this may not be an applicable measurement of impacts for this area in regard to pipelines and well pads.

Item: Section 4.20.3.1, Page 4-133, **Wildlife Impacts**
Comment: "Any demographic response to wellfield development would be a significant impact." This statement is much too conclusive and is not supported by the text which states that, "There is potential for a declining population" that "Current understanding is insufficient to predict how such a demographic response would be manifested" and contains phrases such as 'may' and 'could'.

Item: Section 4.20.3.1, Page 4-134, **Wildlife Impacts**
Comment: "Noise from drilling rigs can exceed 10 dBA above background noise, even if drilling is farther than 0.25 mile from noise sensitive sites such as a greater sage-grouse lek (see Section 3.12 – Noise). The 10 dBA above background limit was specified in the PAPA ROD (BLM, 2000b) as an Administrative Requirement and Condition of Approval. The PAPA DEIS (BLM, 1999a) assumed that a 0.25-mile buffer around leks was sufficient to limit noise from wellfield traffic to 10 dBA above background levels. Holloran (2005) indicates that the 0.25-mile buffer surrounding leks may be insufficient to maintain function of lek habitats due to wellfield development and associated noise."

Below is an excerpt from the BP Amoco letter (Kirk Steinle) to BLM related to comment on the DEIS dated Feb 4, 2000. This comment still applies.

'The mitigation in the RPA states, "Noise from project activities on Federal lands and minerals would be managed near leks while they are actively attended (approximately

March 1 to May 15) during the hours from midnight to 9:00 am so that no more than a 10 dBA increase in background noise occurs at the lek." In Chapter 4 of the document the BLM explains that the male grouse mating display involves an acoustic signal coupled with visual displays so that **constant** (emphasis added) noise could interfere with females attraction to male's displays.... Although the noise level for heavy trucks, dozers, and scrapers exceed the maximum 49dBA suggested limit, these sources are not constant and would likely not overlap the proposed time restrictions..'

Item: Section 4.20.3.1, Page 4-135, **Wildlife Impacts**
Comment: "As discussed earlier, edges are one component of habitat fragmentation. Fragmentation and the amount of edge between disturbed surfaces and wildlife habitat has been considerable through 2006, particularly due to wellfield roads (Table 4.20-1). A study of migratory bird (sagebrush obligate species) includes effects by wellfield development in the Jonah Field Project Area (King and Holmes, 2005). Results of effects of fragmentation on populations are not yet available. Effects of fragmentation to migratory breeding birds and other wildlife (small game, furbearers, and small mammals) would increase considerably from 2006.

This statement is much too conclusive and is not supported by the text in the paragraph it attempts to summarize.

Item: Section 4.20.3.1, Page 4-136, **Wildlife Impacts**
Comment: With the implementation of BMPs and an Erosion Control Re-vegetation and Restoration Plan these surface disturbance impacts identified on this page would be mitigated. ERRP's are required under the 2000 ROD.

Item: Section 4.20.3.1, Page 4-137, **Wildlife Impacts**
Comment: "BLM imposes temporal and spatial limitations for pipeline construction activities around active raptor nest sites. Pipeline construction would not occur within 0.5 mile of active raptor nests or within 1 mile of active bald eagle or ferruginous hawk nests between February 1 and July 31.

These temporal and spatial buffers may be adjusted, based on site-specific conditions. Raptor surveys would be conducted prior to commencement of construction activities from February 1 to July 31 in the nesting season. No impacts to nesting raptors are anticipated as a result of pipeline construction."

The phrase '*to the extent practicable*' should be appended to BLM imposed temporal and spatial limitations to read, 'BLM imposes temporal and spatial limitations *to the extent practicable*'. This statement is supported by adjustment of temporal and spatial buffers based on site-specific conditions.

EXHIBIT A

The parties to IBLA 97-309 and IBLA 97-346 agree that the appeals filed by the State of Wyoming and Cabot Oil & Gas Corporation, et al., should be dismissed, subject to the following amendment and clarification of the records of decision for the Fontenelle and Expanded Moxa Arch natural gas development projects:

1. With respect to the discussion in the records of decision regarding a "level of concern" for NO_x emissions, the parties agree as follows:

> "If this level of emissions is reached, BLM will notify EPA, the Forest Service, and the Wyoming DEQ that further emissions may have an adverse impact on air quality related values. Further, BLM, consistent with its Letter of Agreement for Tracking Nitrogen Oxide Emissions with the Wyoming DEQ dated June 20, 1997, and in cooperation and consultation with Wyoming DEQ, EPA Region VIII, USDA-Forest Service, and other affected agencies, will continue to track air quality in the affected region, and will verify the level of emissions, determine visibility impacts through additional modeling, and determine whether unanticipated visibility impacts are predicted or occurring in order to produce additional documentation that may be required under NEPA. BLM will use this information in making recommendations to EPA regarding air quality and to DEQ regarding permitting for existing leases, and in making decisions regarding future leases on BLM lands.
>
> If visibility impacts are determined to be greater than predicted at 977 tons of NO_x and/or if increased contributions of other pollutants (such as VOCs) result in higher emission levels than stated in the BLM's cumulative air quality impacts analysis, then BLM will conduct additional NEPA analysis and/or additional monitoring. The additional information will be used to make recommendations to DEQ regarding permitting of further development under existing leases, as well as BLM decisions regarding future leases. To the extent authorized by the lease terms and federal or state law, operators may be required to cooperate in the implementation of a supplemental coordinated air quality monitoring program or emissions control program."

2. With respect to the discussion in the records of decision regarding well site and compressor site emissions, the parties agree that the emission figures referred to are not emission limitations. If actual emissions will exceed the figures referred to, additional NEPA documentation may, however, be required. The State of Wyoming Department of Environmental Quality is the permitting authority for air emissions from well and compressor sites.

3. The discussion in the records of decision regarding use of liners on production facilities is amended and clarified by the BLM's September 24, 1997 letter to public land users, attached to BLM's Answer in IBLA 97-346.

BEFORE THE DEPARTMENT OF THE INTERIOR
INTERIOR BOARD OF LAND APPEALS

State of Wyoming,	)	IBLA 97-309
	)	
Cabot Oil & Gas Corporation, Amoco Production Company, Texaco Inc., Vastar Resources, Inc., Union Pacific Resources Company, Snyder Oil Corporation, Marathon Oil Company, Petroleum Association of Wyoming, Enron Oil and Gas Company,	)	IBLA 97-346
	)	
Appellants.	)	

JOINT MOTION FOR ENTRY OF ORDER AMENDING AND CLARIFYING RECORDS OF DECISION

The Bureau of Land Management, the State of Wyoming, and Cabot Oil and Gas Corporation, et al., jointly request the Board to issue an order amending and clarifying the Fontenelle and Expanded Moxa Arch records of decision that are at issue in IBLA 97-309 and IBLA 97-346. The clarifying language agreed to is attached as Exhibit A. With the entry of an order incorporating this language, the parties agree that these appeals are fully and finally resolved and should be dismissed by the Board. The grounds for this motion are as follows:

1. In IBLA 97-309, the State of Wyoming appealed from an air emissions "level of concern" for NO_x that the BLM included in records of decision for the Fontenelle and Expanded Moxa Arch gas development projects located in southwest Wyoming. See Amended Record of Decision for Fontenelle Natural Gas Infill Drilling Projects, March 4, 1997, at 6-8, 13-16; Record of Decision for Expanded Moxa Arch Area Natural Gas Development Project, March 5, 1997, at 5-7, 15-18.

2. In IBLA 97-346, Cabot Oil and Gas Corporation, along with several other companies and the Petroleum Association of Wyoming, appealed the same NO_X "level of concern" in the same records of decision, as well as what appeared to be emission limitations on well and compressor sites. See id. Cabot and three other companies also appealed the "liner requirements" set forth in Appendix A to those records of decision and filed a separate statement of reasons on that issue.

3. The BLM has filed answers in IBLA 97-309 and 97-346. With respect to the NO_X emissions issue, BLM explained that the "level of concern" in the two records of decision was not intended to regulate air quality in southwest Wyoming or otherwise to establish a "cap" on air emissions or oil and gas development. Further, BLM recognized that it does not have authority to limit development on existing leases when the NO_X emissions level of 977 tons is reached. BLM then offered two paragraphs of clarification to amend statements made in the Fontenelle and Expanded Moxa Arch RODs. BLM Answer (on air issues) at 3-4.

4. With respect to the well and compressor sites, BLM clarified that the emission figures in the two RODs "are not emission limitations but are merely the point at which emissions would require additional analysis pursuant to NEPA." BLM Answer (on air issues) at 4. BLM also acknowledged that the permitting authority for air emissions in Wyoming is the Wyoming Department of Environmental Quality. Id. at 8.

5. Finally, with respect to the liner issue, BLM pointed out that, on September 24, 1997, the Wyoming State Director issued an amendment and clarification of the Fontenelle and Expanded Moxa Arch RODs. BLM Answer (on liner issue) at 3.

6. Since BLM filed its answers, counsel for the parties have met to discuss the clarifying language. With some modifications to the clarifying language on the NO_x issue, all parties agree that the BLM's clarification is satisfactory and resolves the issues on appeal.

7. The parties agree that the BLM's clarification of the records of decision on the NO_x issue should be revised to read as follows:

> "If this level of emissions is reached, BLM will notify EPA, the Forest Service, and the Wyoming DEQ that further emissions may have an adverse impact on air quality related values. Further, BLM, consistent with its Letter of Agreement for Tracking Nitrogen Oxide Emissions with the Wyoming DEQ dated June 20, 1997, and in cooperation and consultation with Wyoming DEQ, EPA Region VIII, USDA-Forest Service, and other affected agencies, will continue to track air quality in the affected region, and will verify the level of emissions, determine visibility impacts through additional modeling, and determine whether unanticipated visibility impacts are predicted or occurring in order to produce additional documentation that may be required under NEPA. BLM will use this information in making recommendations to EPA regarding air quality and to DEQ regarding permitting for existing leases, and in making decisions regarding future leases on BLM lands.
>
> If visibility impacts are determined to be greater than predicted at 977 tons of NO_x and/or if increased contributions of other pollutants (such as VOCs) result in higher emission levels than stated in the BLM's cumulative air quality impacts analysis, then BLM will conduct additional NEPA analysis and/or additional monitoring. The additional information will be used to make recommendations to DEQ regarding permitting of further development under existing leases, as well as BLM decisions regarding future leases. To the extent authorized by the lease terms and federal or state law, operators may be required to cooperate in the implementation of a supplemental coordinated air quality monitoring program or emissions control program."

8. To conclude administrative proceedings regarding the issues raised in these appeals, and to avoid disputes in the future over the interpretation of the Fontenelle and Expanded Moxa

Arch records of decision, the parties jointly ask the Board to issue an order that dismisses these appeals subject to the clarifying language agreed to by the parties. The agreed-upon clarifying language is attached as Exhibit A.

Dated: January 14, 1998

Respectfully submitted,

(see next page)

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DENVER:0810333.01

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United States Department of the Interior

OFFICE OF HEARINGS AND APPEALS
Interior Board of Land Appeals
4015 Wilson Boulevard
Arlington, Virginia 22203

IN REPLY REFER TO:

CERTIFIED

JAN 28 1998

IBLA 97-309 STATE OF WYOMING	:	Amended Records of Decision
	:	Fontanelle Natural Gas Infill Drilling Projects
IBLA 97-346 CABOT OIL & GAS CORPORATION	:	Expanded Moxa Arch Natural Gas Development Project
	:	Appeals Dismissed, Cases Remanded

ORDER

The State of Wyoming (the State) and the Wyoming State Office, Bureau of Land Management (BLM), have filed a Joint Motion for Entry of Order Amending and Clarifying Records of Decision (Motion), which was received by this Board on January 15, 1998. Also joining in the Motion are Cabot Oil and Gas Corporation; Amoco Production Company; Texaco Inc.; Vastar Resources, Inc.; Union Pacific Resources Company; Snyder Oil Corporation; Marathon Oil Company; the Petroleum Association of Wyoming; and Enron Oil and Gas Company, all of which filed the appeal docketed as IBLA 97-346. All the parties had appealed from BLM's March 4, 1997, amended Record of Decision (ROD) for the Fontanelle Project and the March 5, 1997, amended ROD for the Moxa Arch project. We had not consolidated the two appeals, although the issues presented are very closely related.

In support of their Motion, the parties state that they have drafted language that clarifies language contained in the two ROD's pertaining to a "level of concern" for certain emissions and the circumstances and manner in which these emissions will be handled. These issues were raised in the State's appeal, IBLA 97-309. The use of liners on production facilities, also discussed in the two ROD's, was satisfactorily clarified by a BLM letter to public land users dated September 24, 1997, and submitted to this Board in IBLA 97-346. The parties state that "[w]ith the entry of an order incorporating this language [in Exhibit A of the Joint Motion], the parties agree that these appeals are fully and finally resolved and should be dismissed by the Board." (Motion at 1.) In light of the agreement reached regarding the language of the clarifications, the Motion to dismiss the appeals is granted.

Therefore, pursuant to the authority delegated to the Board of Land Appeals by the Secretary of the Interior, 43 C.F.R. § 4.1, the appeals are dismissed subject to the clarifications herein described, and the case files are remanded to BLM.

T. Britt Price
Administrative Judge

I concur:

Will A. Irwin
Administrative Judge

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BEFORE THE DEPARTMENT OF THE INTERIOR
INTERIOR BOARD OF LAND APPEALS

State of Wyoming,	)	IBLA 97-309
	)	
Cabot Oil & Gas Corporation, Amoco Production Company, Texaco Inc., Vastar Resources, Inc., Union Pacific Resources Company, Snyder Oil Corporation, Marathon Oil Company, Petroleum Association of Wyoming, Enron Oil and Gas Company,	)	IBLA 97-346
	)	
Appellants.	)	

**JOINT MOTION FOR ENTRY OF ORDER
AMENDING AND CLARIFYING RECORDS OF DECISION**

The Bureau of Land Management, the State of Wyoming, and Cabot Oil and Gas Corporation, et al., jointly request the Board to issue an order amending and clarifying the Fontenelle and Expanded Moxa Arch records of decision that are at issue in IBLA 97-309 and IBLA 97-346. The clarifying language agreed to is attached as Exhibit A. With the entry of an order incorporating this language, the parties agree that these appeals are fully and finally resolved and should be dismissed by the Board. The grounds for this motion are as follows:

1. In IBLA 97-309, the State of Wyoming appealed from an air emissions "level of concern" for NO_X that the BLM included in records of decision for the Fontenelle and Expanded Moxa Arch gas development projects located in southwest Wyoming. See Amended Record of Decision for Fontenelle Natural Gas Infill Drilling Projects, March 4, 1997, at 6-8, 13-16; Record of Decision for Expanded Moxa Arch Area Natural Gas Development Project, March 5, 1997, at 5-7, 15-18.

BEFORE THE U.S. DEPARTMENT OF THE INTERIOR
BOARD OF LAND APPEALS

BP America Production Co.,	)	
	)	IBLA No. 2006-158
Appellant.	)	

JOINT MOTION TO DISMISS APPEAL

BP America Production Co. ("BP") and the Bureau of Land Management, Wyoming State Office ("BLM"), jointly move for dismissal of BP's appeal. The parties agree that the appeal should be dismissed based on the following:

(1) BP interpreted the BLM's Record of Decision for the Jonah Infill Project ("Jonah ROD") as possibly establishing a "cap" on air emissions from oil and gas operations. In two prior appeals involving other oil and gas projects in southwest Wyoming, BLM agreed that it could not impose a cap on air emissions from oil and gas development, and that other agencies regulate air emissions. A copy of the joint motion and order resolving the prior appeals (IBLA Docket Nos. 97-309, 97-346) are attached as Exhibit A.

(2) The BLM has advised BP that, consistent with the resolution of IBLA Docket Nos. 97-309 and 97-346, the 80% emissions reduction scenario described in the Jonah ROD does not impose a cap on air emissions (directly or indirectly through modeling). Accordingly, BP has determined that it need not pursue this appeal.

(3) The parties recognize that the BLM's modeling of air impacts for the Final Environmental Impact Statement was designed to and does conservatively overestimate likely air impacts of the Jonah Infill project. In re-running the air dispersion model as

contemplated by the Jonah ROD and processing permit applications for specific operations, BLM will take into account available monitoring data and other information on actual emissions in an effort to develop a model configuration that yields more accurate estimates of air impacts.

(4) The parties agree and acknowledge that, if BLM subsequently denies a permit to conduct operations based on the air quality provisions of the Jonah ROD, BP can appeal such a decision at that time and the dismissal of this appeal shall be without prejudice to the issues BP may raise in such an appeal.

(5) BP and BLM represent that both intervenors, the State of Wyoming and EnCana Oil & Gas (USA) Inc., support this motion.

Dated: May 10, 2006.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Joint Motion to Dismiss Appeal was sent by certified mail, return receipt requested, on May 10, 2006, addressed to the following:

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3550665_1.DOC

Attachment 2

API Draft Report
CALPUFF CHEMISTRY UPGRADE
Prepared by

Prakash Karamchandani,
Shu-Yun Chen and Christian Seigneur
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DRAFT

CALPUFF CHEMISTRY UPGRADE

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Document CP277-07-01

November 2007

TABLE OF CONTENTS

1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has adopted CALPUFF (Scire et al., 2000) as the preferred model for assessing long range transport of pollutants and their impacts on Federal Class I areas under the Prevention of Significant Deterioration (PSD) program and on a case-by-case basis for certain near-field applications involving complex meteorological conditions. CALPUFF is also the preferred option in Best Available Retrofit Technology (BART) determinations for assessing the visibility impacts of one or a small group of sources.

In most of the United States, visibility impairment is primarily caused by light extinction from fine particles ($PM_{2.5}$) in the atmosphere. The key components of $PM_{2.5}$ contributing to visibility impairment include sulfate, nitrate, ammonium, organic carbon, elemental carbon, and crustal material. Many of these components are secondary, i.e., they are formed as a result of the chemical transformations of the primary emitted pollutants. These transformations can occur in the gas phase and in cloud droplets as well as heterogeneously on particles and droplet surfaces. Thus, a model, such as CALPUFF, which is applied for assessing the impacts of sources on visibility and air quality, should incorporate an adequate treatment of the relevant chemical processes including gas-phase chemistry, aqueous-phase chemistry and aerosol formation. However the current treatment of atmospheric chemistry in CALPUFF is highly simplified and inadequate for simulating particulate matter (PM) formation, as shown in several recent studies (Karamchandani et al., 2006; Santos and Paine, 2006; Morris et al., 2005; 2006).

In this work, we have incorporated several improvements to the treatment of chemistry in CALPUFF. These improvements were incorporated in both the unofficial Version 6 release (April 2006 release, available from the model developers), as well as the official EPA Version 5.8 release (June 2007). The improvements include both corrections to errors in the existing gas-phase chemistry module, as well as incorporation of new science modules for inorganic and organic aerosols and aqueous-phase chemistry. Section 2 describes the changes to CALPUFF. Section 3 presents the results of simulations with the original and improved versions of CALPUFF using an existing plume chemistry CALPUFF modeling database. Section 4 presents results from sensitivity studies conducted with CALPUFF Version 5.8, as well as results from sensitivity studies conducted with box-model implementations of the original and revised CALPUFF HNO_3/nitrate partitioning schemes. Section 5 provides conclusions as well as recommendations for further evaluation to validate some of the new chemistry modules that could not be validated in this study because the modeling database did not include the required measurements.

2. IMPROVEMENTS TO CALPUFF

The improvements to CALPUFF described in the following sections were made to two versions of CALPUFF that were available at different times during the course of this project. We first made improvements to the unofficial Version 6 release (dated April 2006), which was available from the model developers). At that time, the official U.S. EPA release of CALPUFF was Version 5.7, dated July 2004. We used the developer's Version 6 release for the improvements, since this release had many improvements as compared to the older official release. Subsequently, towards the end of the current study, the U.S. EPA officially released Version 5.8 of CALPUFF in June 2007. On API's request, the improvements made to Version 6 of CALPUFF were reincorporated into the official Version 5.8 release.

2.1 Improvements to Gas-phase Chemistry

CALPUFF provides several options to calculate the conversion rates of SO_2 to sulfate and NO_x to nitrate. The simplest option is for the user to specify diurnally-varying transformation rates. The second option is based on the MESOPUFF II scheme, in which the pseudo-first-order constants for the daytime gas-phase conversions of SO_2 to sulfate and NO_x to nitric acid and other (organic) nitrates are parameterized as functions of the background ozone concentration (provided as input to CALPUFF), the total solar radiation intensity, the stability index, and the plume NO_x concentrations. Constant nighttime gas-phase SO_2 and NO_x conversion rates are specified as default values in the model. Aqueous-phase conversion of SO_2 to sulfate is parameterized as a function of the relative humidity. The third option is the RIVAD/ARM3 chemical scheme, which treats the NO and NO_2 conversion process in addition to the conversion of NO_2 to inorganic nitrate and SO_2 to sulfate. The improvements made to CALPUFF in this study were to the RIVAD/ARM3 scheme, as discussed below.

The RIVAD/ARM3 scheme is derived from the PLUVUE scheme of Bergstrom et al. (1981). This scheme assumes low background VOC concentrations and is not suitable for urban regions or areas with significant biogenic emissions. The NO-NO_2-O_3 chemical system is first solved to get pseudo-steady-state concentrations of NO, NO_2, and O_3. During the day, this system consists of the NO_2 photolysis reaction to yield NO and O_3 and the NO-O_3 titration reaction to yield NO_2. During the night, only the NO-O_3 titration reaction is considered. The RIVAD/ARM3 scheme is incorrectly implemented in CALPUFF because the background O_3 concentration is used as the initial O_3 concentration at each puff chemistry time step (i.e., the plume O_3 concentration does not evolve as a function of the downwind distance but instead it is replenished at each time step). In reality, the high NO concentrations in the plume deplete the O_3 concentrations in the near field and, as a result, OH concentrations are very low and the gas-phase rates of NO_2 and SO_2 oxidation to HNO_3 and H_2SO_4, respectively, are negligible (Richards et al., 1981; Gillani et al., 1998; Karamchandani et al., 1998, Karamchandani and Seigneur, 1999). In CALPUFF, the hydroxyl radical, OH, is produced from the photolysis of O_3 and the OH concentration is calculated from the final O_3 concentration after the solution of the NO-NO_2-O_3 system. Since CALPUFF does not account for the depletion of O_3 in the plume, OH concentrations are overestimated in the near field. This, in turn, leads to the overestimation of the rates of HNO_3 and H_2SO_4 formation of in the near field.

To correct this error in CALPUFF's RIVAD/ARM3 scheme, we made the following modifications to the code. First, we keep track of the puff O_3 concentrations between time steps. Then, at each chemistry time step, the puff O_3 concentration is calculated as a weighted average of the previous time step's concentration and the background concentration. The weighting factors are determined from the change in volume of the puff between the previous and current time step. Note that we employ the same approach to calculate the puff H_2O_2 concentrations, required for the aqueous-phase chemistry module described in Section 2.4.

In addition to these corrections, we also updated the oxidation rates of SO_2 and NO_2 by OH to the rates employed in contemporary photochemical and regional PM models, such as the U.S. EPA's Community Multiscale Air Quality (CMAQ) model.

Note that this updated RIVAD/ARM3 scheme is implemented as a new option (MCHEM=5) in CALPUFF. We have retained the option of using the original RIVAD/ARM3 scheme (MCHEM=3), since that scheme is part of the official EPA release and can only be discarded after EPA approves the updated RIVAD/ARM3 scheme.

It should also be pointed out that the changes to the RIVAD/ARM3 scheme described here correct errors in the scheme, but do not address one of the shortcomings of the treatment of gas-phase chemistry in CALPUFF, namely that it is overly simplified and does not provide an adequate treatment of atmospheric chemistry. This shortcoming can be overcome by either 1) implementing comprehensive gas-phase chemistry mechanisms, such as CB-IV, into CALPUFF or 2) adapting CALPUFF to use the output of comprehensive three-dimensional grid models, such as CMAQ or CAMx, to provide the background concentrations of relevant species, such as ozone, hydrogen peroxide and ammonia. The first option was not considered for the study described here, since it would require significantly more resources to implement and would slow the model considerably, making it impractical for its intended use. In addition, other reactive puff models, such as SCICHEM (Karamchandani et al., 2000), are available for applications requiring a more comprehensive treatment of gas-phase chemistry. The second option is more practical to implement but was not part of the scope of work for this study. It may be considered as a candidate for future enhancement of CALPUFF (see Section 5).

Thus, the primary objective of this study was to correct the RIVAD/ARM3 scheme, as described above, and to implement new modules for inorganic and organic PM and aqueous-phase chemistry that were based on existing modules used in SCICHEM as well as three-dimensional models such as CMAQ, CMAQ-MADRID and CAMx. The following sections provide further details on the implementation of these new modules.

2.2 Improvements to Treatment of Inorganic PM

CALPUFF uses a simple approach to simulate the partitioning of nitrate and sulfate between the gas and particulate phases. This approach is used for both the MESOPUFF chemistry and the RIVAD/ARM3 chemistry options. In this approach, sulfate is assumed to be present totally in the particulate phase (which is an appropriate treatment), and nitrate is assumed to be formed by the reaction between nitric acid and ammonia. A simple stoichiometric thermodynamic model is used to estimate the partitioning of total inorganic nitrate between gas-phase nitric acid and particle-phase ammonium nitrate. Total ammonia concentrations are provided as background values to the model, and the available ammonia for creating ammonium nitrate is computed as total ammonia minus sulfate (with a factor of two to account for the stoichiometry of ammonium sulfate) to account for the preferential scavenging of ammonia by sulfate. Then, the gas-particle partitioning of total nitrate is estimated using the available ammonia concentration, the total nitrate concentration, and the equilibrium constant for the HNO_3-NH_3-NH_4NO_3 system (calculated as a function of the temperature and relative humidity).

For this study, we implemented an additional treatment for inorganic gas-particle equilibrium. This treatment is based on the ISORROPIA model of Nenes et al. (1999), version 1.7 (i.e., the version currently used in CMAQ 4.6). ISORROPIA provides an appropriate compromise between accuracy and computational efficiency for the calculation of the partitioning of inorganic PM. This improvement is similar to what was recommended (Seigneur et al., 1999) and implemented for the improvement of PM formation in REMSAD. ISORROPIA is currently used in several 3-D air quality models such as CMAQ, CMAQ-MADRID, CAMx and REMSAD. Thus, with this new module, CALPUFF now includes a treatment of inorganic PM formation that is consistent with the state of the science in air quality modeling. Note that the incorporation of the ISORROPIA treatment in CALPUFF has very little impact on its computational efficiency.

As in the case of the gas-phase chemistry mechanism, we have also retained the original CALPUFF treatment for inorganic PM for consistency with EPA's distribution of CALPUFF. The original treatment in CALPUFF is used with the MESOPUFF chemistry option (MCHEM=1) and the original RIVAD/ARM3 scheme (MCHEM=3), while the ISORROPIA treatment implemented in this study is employed with the corrected RIVAD/ARM3 scheme (MCHEM=5 or MCHEM=6).

2.3 Improvements to Treatment of Organic PM

CALPUFF was updated for the Wyoming Department of Air Quality to include a treatment for the formation of secondary organic aerosols (SOA) from VOC emissions (Scire et al., 2001). Note that the CALPUFF User's Guide (Scire et al., 2000) does not describe this option (MCHEM=4), nor is this update documented at the official CALPUFF web site (http://www.src.com/calpuff/calpuff1.htm).

The current CALPUFF treatment includes SOA formation from aromatics (represented by toluene and xylenes) and monoterpenes (represented by α-pinene and β-pinene). Note that this treatment is not coupled with the RIVAD/ARM3 NO_x/SO_x scheme, i.e., this option only allows the simulation of terpene and aromatic emissions and the formation of SOA. Thus, a separate simulation must be performed if one also needs to calculate secondary PM formation from SO_2 and NO_x emissions.

In this study, we have added a treatment for SOA that is coupled with the corrected RIVAD/ARM3 scheme described in Section 2.3. The treatment is based on the algorithm that is used in CMAQ-MADRID for anthropogenic SOA formation. CMAQ-MADRID (Zhang et al., 2004) is a 3-D model that is publicly available via www.cmascenter.org. The MADRID algorithm (Pun et al., 2005) currently treats SOA formation from both anthropogenic and biogenic VOC emissions. For this work, we have not included biogenic SOA formation because it results from the emissions of VOC from vegetation; CALPUFF, being a puff model, is unlikely to be applied in this context and a 3-D model would be needed to correctly treat biogenic SOA formation. Thus, we have only included the anthropogenic SOA component of MADRID in CALPUFF. However, the original CALPUFF biogenic SOA option is still available for users interested in applying CALPUFF for biogenic sources.

Anthropogenic SOA formation results from the oxidation of aromatic compounds, long-chain alkanes and alkenes and some PAH. The new CALPUFF SOA module treats SOA formation from mono-substituted aromatics (represented by toluene), poly-substituted aromatics (represented by xylenes), long-chain alkanes (represented by a 16-carbon alkane) and gas-phase PAH (represented by methyl-naphthalene). Alkenes are not treated at this point due to a lack of experimental data for long-chain aliphatic alkenes (some modelers have used cyclohexene as a surrogate compound for long-chain alkenes). Benzene has also been suggested as a SOA precursor; however, insufficient quantitative information is available at the moment to treat it in a model (Pun and Seigneur, 2007).

The SOA formation algorithms are based on the results of smog chamber experiments for the aromatics (Odum et al., 1997) and from chemical kinetic simulations conducted with a comprehensive mechanism (Griffin et al., 2005) for alkanes and PAH (smog chamber experimental data are not available for alkanes and PAH at the moment). The partitioning of condensable products from the oxidation of the VOCs into the gas and particulate phases is based on the absorption algorithm of Pankow (1994).

The following reactions for the oxidation of anthropogenic VOC precursors of SOA were added to the RIVAD/ARM3 scheme with the SOA option (MCHEM=6):

TOL + OH	=>	0.071 TOLAER1 + 0.138 TOLAER2
XYL + OH	=>	0.038 XYLAER1 + 0.167 XYLAER2
ALK + OH	=>	1.173 ALKAER
PAH + OH	=>	0.156 PAHAER1 + 0.777 PAHAER2

In the above set of equations, TOLAER1, TOLAER2, etc. are the condensable products from the oxidation of the various VOCs. The stoichiometric coefficients were derived from smog chamber experiments or kinetic simulations with a comprehensive mechanism. The OH radical concentration is determined from the RIVAD/ARM3 scheme, as discussed in Section 2.1.

The partitioning of the condensable products into the particle and gas phases is determined from the following equation:

$$K_i = \left(\frac{A_i / M_{sum}}{G_i} \right) \tag{1}$$

In Equation 1, K_i is the partition coefficient ($m^3\ \mu g^{-1}$), A_i and G_i are the mass concentrations ($\mu g\ m^{-3}$ air) of species i in the particulate- and gas-phase, respectively, and M_{sum} ($\mu g\ m^{-3}$ air) is the sum of primary organic carbon (nonvolatile) and secondary organic carbon (semi-volatile) in the particulate phase that serve as the organic absorbing medium. Note that the smog chamber experiments from which the partition coefficients are derived were conducted at temperatures higher than typical ambient temperatures. Thus, a temperature correction based on the Clausius-Clapeyron equation is applied to determine K_i:

$$K_i(T) = K_i^* \frac{T}{T^*} \exp\left[\frac{\Delta H_{vap,i}}{R} \left(\frac{1}{T} - \frac{1}{T^*} \right) \right] \tag{2}$$

where $K_i(T)$ and K_i^* are the partition coefficients at temperature T and a reference temperature T^*, respectively. R is the ideal gas constant and $\Delta H_{vap,i}$ is the enthalpy of vaporization of the pure species i. The values of the partition coefficients at 298 K and the enthalpies of vaporization are presented in Table 2-1. Note that the original CALPUFF SOA module only applies the first part of the temperature correction in Equation 2, i.e.

$$K_i(T) = K_i^* \frac{T}{T^*} \tag{3}$$

From Equation 3, we see that the partition coefficient in the original CALPUFF formulation always decreases as temperature decreases, which is incorrect. For example, the enthalpy of vaporization for SOA products from toluene is estimated to be 73 kJ $mole^{-1}$. For an ambient temperature of 298 K with a reference temperature of 310 K, Equation 2 yields a partition coefficient at the ambient temperature that is about 3 times larger than that at the reference temperature. In contrast, Equation 3 gives a value for the partition coefficient at the ambient temperature that is about 96% of the value at the reference temperature. Thus, the original CALPUFF formulation significantly underestimates the partition coefficient (by more than a factor of 3 for this example).

Table 2-1. Partition coefficients (at 298K) and heats of vaporization of condensable species.

Condensable Species	**K** (m^3 μg^{-1})	ΔH_{vap} **(kJ mole^{-1})**
TOLAER1	0.1586	72.67
TOLAER2	0.0057	72.67
XYLAER1	0.1257	72.67
XYLAER2	0.0042	72.67
ALKAER	0.0229	72.67
PAHAER1	0.0150	72.67
PAHAER2	0.0020	72.67

From Equation 1, we see that the partitioning of the condensable product between the gas and particle phases also depends on the absorbing medium, i.e., the total organic mass, consisting of both primary (emitted) organic carbon as well as secondary organic carbon. Thus, it is necessary to provide an estimate for the concentrations of primary organic carbon. CALPUFF already allows the user to specify a background total fine PM concentration and a value for the fraction of this concentration that consists of organic carbon. In addition, we have included an option for emitted primary organic carbon to be carried as a species in CALPUFF when the new SOA chemistry option is selected. Thus, the total primary organic carbon is the sum of the background organic carbon and the emitted carbon from the source that is being simulated by CALPUFF.

The calculation of SOA formation that we have implemented in CALPUFF should be seen as a screening calculation. In the RIVAD/ARM3 scheme, the OH concentration is calculated in CALPUFF from NO_x/O_3 chemistry and the VOC/NO_x chemistry is not treated. Therefore, the OH concentration estimates will be uncertain if VOC concentrations are significant. If SOA formation appears to be a potential issue, a more refined calculation can be performed using a model with a comprehensive treatment of VOC/NO_x chemistry, which will be computationally more demanding.

2.4 Implementation of Aqueous-phase Chemistry and Wet Removal

The aqueous-phase formation of sulfate in CALPUFF's RIVAD/ARM3 scheme is currently approximated with a simplistic treatment that uses an arbitrary pseudo-first-order rate in the presence of clouds (0.2% per hour), which is added to the gas-phase rate (Scire et al., 2000). There is no explicit treatment of aqueous-phase SO_2 oxidation chemistry.

In this study, we have incorporated into CALPUFF a mechanistic treatment of sulfate formation in clouds that is based on the treatment (Walcek and Taylor, 1986) used in EPA's CMAQ. The CMAQ aqueous-phase mechanism represents sulfate formation with five reactions and includes the calculation of pH since some reactions depend on pH. These five reactions include oxidation by O_3, oxidation by H_2O_2, trace metal catalyzed oxidation, oxidation by organic peroxides, and oxidation by peroxyacetic acid.

For this study, we have included the first three reactions in the new aqueous-phase chemistry module. For the first reaction, the O_3 concentration is calculated by the RIVAD/ARM3 scheme. As described in Section 2.1, we have corrected CALPUFF so that the O_3 concentration that is input to the RIVAD/ARM3 scheme is a weighted average of the O_3 concentration in the puff at the previous time step and the background O_3 concentration. A similar approach is used to adjust the H_2O_2 concentration that is input to the aqueous-phase chemistry module for the second reaction. This is important because the $SO_2 + H_2O_2$ in the aqueous-phase is very fast and H_2O_2 is usually the limiting reactant. Thus, it is consumed rapidly and the puff H_2O_2 concentration at the end of the aqueous-phase chemistry time step is zero or very small. If the H_2O_2 concentration at the next time step does not reflect this puff history, then aqueous-phase SO_2 oxidation rates in CALPUFF will be overestimated. Finally, for the third reaction, typical background concentrations of the trace metals (iron and manganese) are used in the code.

An iterative approach is used to calculate the pH of cloud water from the concentrations of the various species in solution (HSO_3^-, $SO_3^=$, NO_3^-, HSO_4^-, $SO_4^=$, HCO_3^-, $CO_3^=$, OH^- and NH_4^+). The bicarbonate (HCO_3^-) and carbonate ($CO_3^=$) ion concentrations are based on a background value of 340 ppm for CO_2.

The aqueous-phase chemistry module implemented in this work also includes the information required to calculate the scavenging and wet deposition of soluble gases and particles by precipitating clouds. This information is used to calculate scavenging coefficients that are used in place of the default CALPUFF scavenging coefficients.

The new CALPUFF aqueous-phase chemistry module requires cloud liquid water contents for its calculations. Since this variable is not yet part of the CALPUFF meteorological inputs, we use liquid water contents of 0.1 g m^{-3} and 0.5 g m^{-3} for non-precipitating and precipitating clouds, respectively. Note that modifying CALMET, the CALPUFF meteorological pre-processor, to prepare meteorological input files that include liquid water content was out of the scope of this study.

The new aqueous-phase chemistry option (MAQCHEM=1) is included with both the new chemistry options discussed previously (MCHEM=5 and MCHEM=6). Note that the aqueous-phase chemistry flag, MAQCHEM, was in the original CALPUFF, but could not be selected since there was no aqueous-phase chemistry treatment in the original CALPUFF. Thus, when the user selects MAQCHEM=1 in the original CALPUFF, an error message is printed stating that the aqueous-phase chemistry option is not available. MAQCHEM=0 is the only option allowed in the original CALPUFF. For consistency with the official EPA release of CALPUFF, MAQCHEM=1 is only available in the new CALPUFF when the selected chemistry option is MCHEM=5 or MCHEM=6.

2.5 User Guidance for New CALPUFF Chemistry Options

In this section, we provide guidance to CALPUFF users that would be using the new chemistry options implemented in this project. This section is in lieu of an updated CALPUFF User's Guide, since the official guide is maintained and distributed by the CALPUFF developers and the U.S. EPA. As pointed out previously, this guide was prepared in 2000 and has not been updated to reflect many of the changes and improvements made to CALPUFF during the intervening time period, including the implementation of the SOA module for the Wyoming Department of Environmental Quality.

For the updated RIVAD/ARM3 chemistry scheme and the ISORROPIA inorganic aerosol module, the only change required is to select MCHEM=5 as the chemistry option in the CALPUFF control file. There are no changes to the input files.

If the CALPUFF user is also interested in calculating SOA formation from the source emissions, then the desired chemistry option in the control file is MCHEM=6. Note that this option also includes the updated RIVAD/ARM3 chemistry scheme and the ISORROPIA inorganic aerosol module, so it is a superset of the previous option (MCHEM=5). Thus, the user can also simulate SO_x and NO_x transport and chemistry and inorganic PM formation with this option. The control file also needs to be updated to include the additional species associated with the SOA treatment. These species include the precursor VOCS toluene ("TOL"), xylene ("XYL"), long-chain alkanes ("ALKH") and polycyclic aromatic hydrocarbons ("PAH"), the condensable products from these species and their particle-phase counterparts, and primary organic carbon ("POC"). The condensable products from the four VOC species are "TOLAER1", "TOLAER2", "XYLAER1", "XYLAER2", "ALKHAER", "PAHAER1", and "PAHAER2". The particle-phase counterparts of these species are "ATOLA1", "ATOLA2", "AXYLA1", "AXYLA2", "AALKHA", "APAHA1" and "APAHA2". A sample control file for this option is provided with the code distribution. For the SOA option, the emissions input file also needs to be updated to include emissions of the VOC species of interest and primary organic carbon emissions if available. Note that it is not necessary to provide emissions of all species. For example, if a given source only emits the aromatic VOCs ("TOL" and "XYL") then all the other species can be designated as non-emitted species in the control file, and only "TOL" and "XYL" emissions are required in the emissions file.

The aqueous-phase chemistry option (MAQCHEM=1) is available with both the new chemistry options (MCHEM=5 and MCHEM=6) but not with the original CALPUFF chemistry options. However, it is not necessary to activate the aqueous-phase chemistry option for MCHEM=6 when there are no SO_2 and NO_x emissions from the source being simulated. This option requires the user to specify H_2O_2 concentrations in either a separate observations data file (hourly) or as monthly values in the control file. Note that the CALPUFF developers have already included the code necessary to read H_2O_2 concentrations in CALPUFF, since they were probably intending to implement an aqueous-phase chemistry module at some point.

3. MODEL SIMULATION RESULTS

The changes to CALPUFF were tested using a plume chemistry database consisting of helicopter measurements of the plume from a large coal-fired power plant in central Tennessee. The power plant (Cumberland) is operated by the Tennessee Valley Authority (TVA), and is located approximately 80 km to the west-northwest of downtown Nashville. It is the largest single source of NO_x emissions (~20 tons of NO_x/hour) in the region. Plume measurements were taken in July 1999 by the TVA Bell 205 helicopter (Imhoff et al., 2000). The gas analyzers included an O_3 monitor, an SO_2 monitor, as well as NO, NO_2, NO_x, and NO_y monitors.

As discussed in Section 2, we incorporated the chemistry improvements into two separate versions of CALPUFF. Most of the simulations described in this section were conducted with the unofficial release (Version 6) of CALPUFF. When the latest official release of CALPUFF (Version 5.8) became available later during the project, we conducted additional simulations, some of which are described in this section, while the remaining are described in Section 4.

3.1 Description of Simulations

CALPUFF simulations were conducted for 3 days in July 1999: July 6, July 13, and July 15. July 6 was a clear day with light winds from the west. On July 13, the conditions were partly cloudy and hazy and the winds were moderate from the north. July 15 was hot and hazy with low to modèrate winds from the south-west. A total of 37 sampling traverses of the Cumberland plume were conducted during these three days. However, many of these traverses were a few minutes apart at the same downwind distance from the power plant, and had similar plume characteristics. Thus, we present CALPUFF results for selected traverses at different representative downwind distances. Table 3-1 lists the plume traverses that were simulated.

Table 3-1. Plume sampling summary for selected flights.

Date	Plume Traverse	Start Time (GMT)	Average Sampling Altitude (m)	Average Distance (km) from the Source
July 6, 1999	187003	17:19	496	10.6
	187006	17:53	496	31.3
	187010	21:05	496	64.7
July 13, 1999	194004	17:35	423	15.8
July 15, 1999	196001	16:20	419	16.6

Three-dimensional meteorological fields for the CALPUFF simulations were generated with CALMET for a previous study (Karamchandani et al., 2006), using hourly surface and upper air data from four sites (Dickson, Gallatin, Eagleville and Cumberland) in the region. The first three of these sites are about 29 km southeast, 113 km east and 120 km southeast, respectively, of Cumberland, the source location. The CALMET/CALPUFF domain was centered on the source location, and extended 400 km in the east-west direction and 296 km in the north-south direction, with a horizontal grid spacing of 4 km. The vertical domain extended to 2 km, and the vertical grid spacing varied from 20 m at the surface to 400 m at the top. The landuse data for the simulations were developed from U.S Geographical Survey (USGS) data. Default values were used for albedo, Bowen ratio, soil heat flux, anthropogenic heat flux, and leaf area index. The diagnostic wind module of CALMET was used along with computation of kinematic effects, slope flow effect, and Froude number adjustment. The maximum radius of influence for a station was chosen as 100 km. For the calculation of mixing heights, default options were mostly chosen. The maximum mixing height was limited to 2 km.

Hourly-varying SO_x and NO_x emissions from the two Cumberland units that were operational in 1999 were used in the simulations. For the tests of the secondary organic aerosol (SOA) module, hypothetical emissions of the two aromatics, toluene and xylene, were assigned to the power plant. We did not include emissions of PAH and higher alkanes, because the original CALPUFF SOA module does not treat these species. For the tests of the new aqueous-phase chemistry module, we assumed 5% cloud cover everywhere (the original meteorological files from CALMET did not have any cloud cover during the time period of the simulation). Fixed background concentrations of 60 ppb for O_3, 10 ppb for ammonia and 1 ppb for H_2O_2 (for the aqueous-phase chemistry module) were used in the simulations.

We begin our discussion of the CALPUFF results by presenting the differences between the new and original (where applicable) versions of the CALPUFF chemistry modules. However, for the aqueous-phase chemistry tests, we only present the results for the new version of CALPUFF. We do this because the original CALPUFF did not have an explicit treatment of aqueous-phase chemistry, and the 0.2 percent per hour rate that was used to parameterize aqueous-phase chemistry had a negligible effect on model results. We then perform a comparison (limited by available data) with gas-phase plume measurements of SO_2, NO, NO_2 and NO_y.

3.2 Effect of Modifications in RIVAD/ARM3 Scheme

In this section, we determine the effect of the modifications to the RIVAD/ARM3 scheme described in Section 2.1. These changes include 1) the corrections to CALPUFF to carry the puff O_3 concentrations, and 2) updates to the rate constants for SO_2 and NO_2 oxidation to sulfate and total nitrate, respectively. As discussed in Section 2.1, the first modification will lead to lower O_3 concentrations (and consequently to lower OH concentrations) in the early stages of the plume, resulting in lower NO to NO_2 conversion, and less OH available for the SO_2 to sulfate and NO_2 to nitrate conversion. The second modification results in lower SO_2 oxidation rates (about 34% lower at 298 K and 1 atm) and higher NO_2 oxidation rate constants (about 21% higher at 298 K and 1 atm) than the original RIVAD/ARM3 rate constants.

Figure 3-1 shows plume NO and NO_2 concentrations for plume traverse 3 on July 6, 1999 (referred to as traverse 187003), at a downwind distance of about 11 km from the point source. The dotted line (MCHEM=3) shows the results for the original CALPUFF RIVAD/ARM3 scheme and the solid line (MCHEM=5) shows the results for the revised scheme. The figure shows that NO concentrations in the plume are higher (by about 5%) with the revised scheme than with the original scheme. Correspondingly, the NO_2 concentrations are lower (by about 2.2%) with the revised scheme as compared to the concentrations with the original scheme. These results are consistent with the changes described above.

Figure 3-2 shows plume sulfate and total nitrate (NO_z) concentrations for traverse 187003. As expected, with the revised RIVAD/ARM3 scheme, CALPUFF predicts lower sulfate concentrations (by about 9%) than with the original scheme. This is due to both the lower OH concentrations and SO_2 oxidation rate constants in the updated scheme as compared to the original scheme. In contrast, we see that NO_z concentrations are slightly larger (by about 1.4%) with the revised scheme than with the original scheme because the higher NO_2 oxidation rate constant more than compensates for the lower OH concentration in the revised scheme.

Figure 3-3 shows the NO and NO_2 results for plume traverse 6 on July 6, 1999 (traverse 187006) at about 31 km downwind of the power plant. At this distance, we see that both NO and NO_2 concentrations with the revised RIVAD/ARM3 scheme are slightly lower than those with the original scheme. The NO results are in contrast to those for the traverse at a downwind distance of 11 km, shown earlier in Figure 3-1. It appears that at larger downwind distances, the higher NO_2 to nitrate oxidation rate constant in the revised scheme changes the equilibrium of the NO-NO_2-O_3 system, resulting in more conversion of NO to NO_2. From Figure 3-4, which shows the sulfate and total nitrate concentration profiles, we see that there is indeed more total nitrate (about 5.5%) produced with the revised scheme (due to the higher NO_2 oxidation rate constant). The sulfate produced with the revised scheme is about 23% lower than that with the original scheme.

The results for plume traverse 10 on July 6, 1999 (traverse 187010) at a downwind distance of 65 km are shown in Figures 3-5 and 3-6. The results are qualitatively similar to those for traverse 187006.

Figures 3-7 and 3-8 show the results for traverse 4 on July 13, 1999 (traverse 194004) at a downwind distance of about 16 km from the power plant. The results are consistent with those for the 11 km plume traverse (187001) on July 6, 1999. The results for traverse 1 on July 15, 1999 (traverse 196001) at a downwind distance of 17 km, shown in Figures 3-9 and 3-10, are also qualitatively similar.

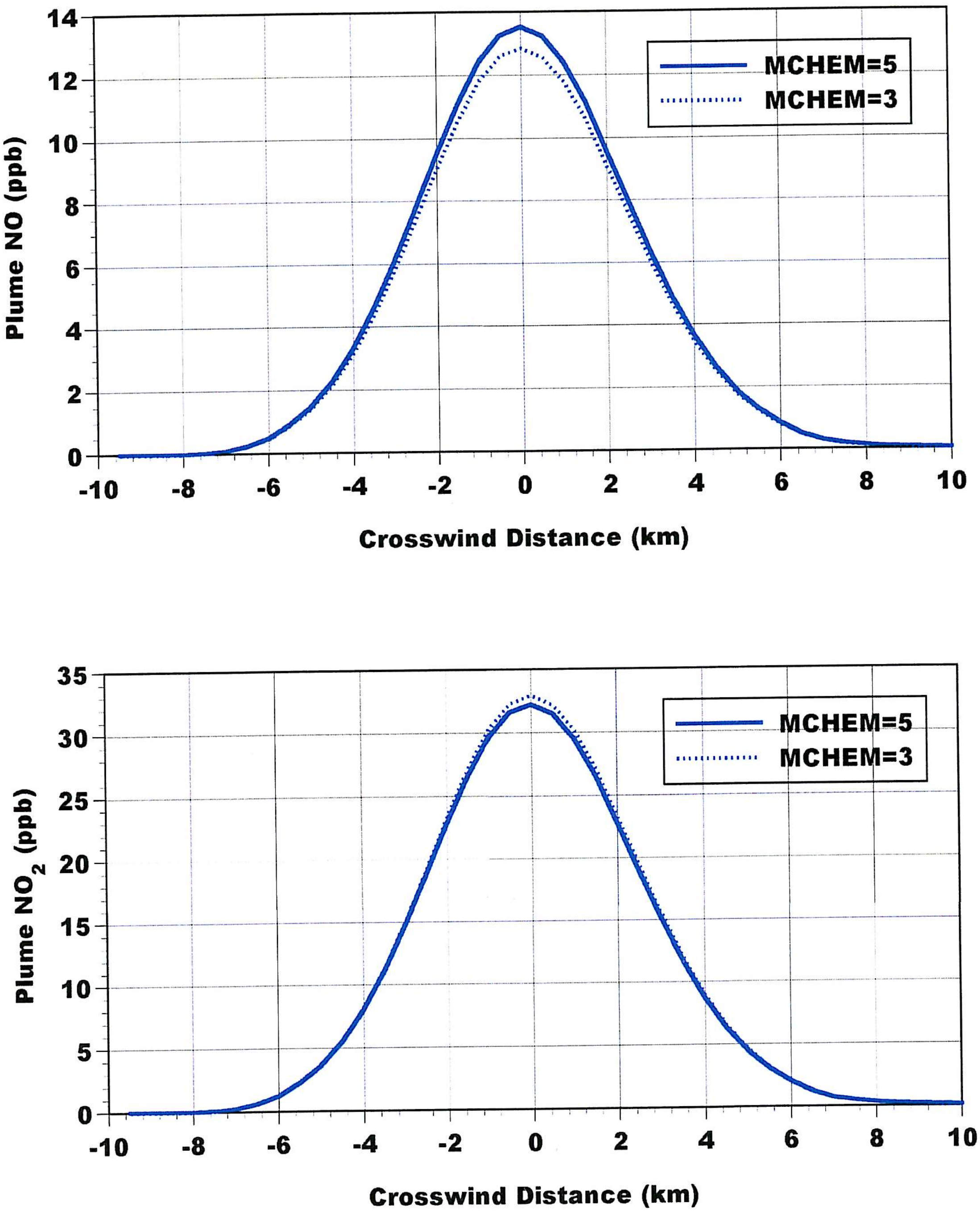
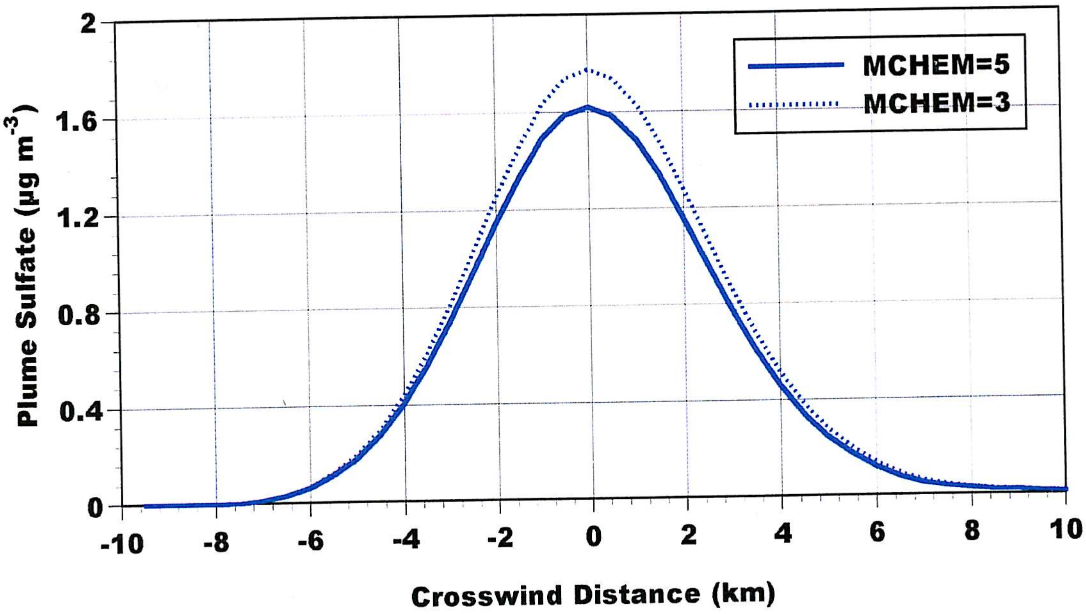


Figure 3-1. NO and NO_2 concentration profiles for plume traverse 187003. MCHEM=3 refers to the original CALPUFF RIVAD/ARM3 formulation, while MCHEM=5 refers to the corrected formulation.



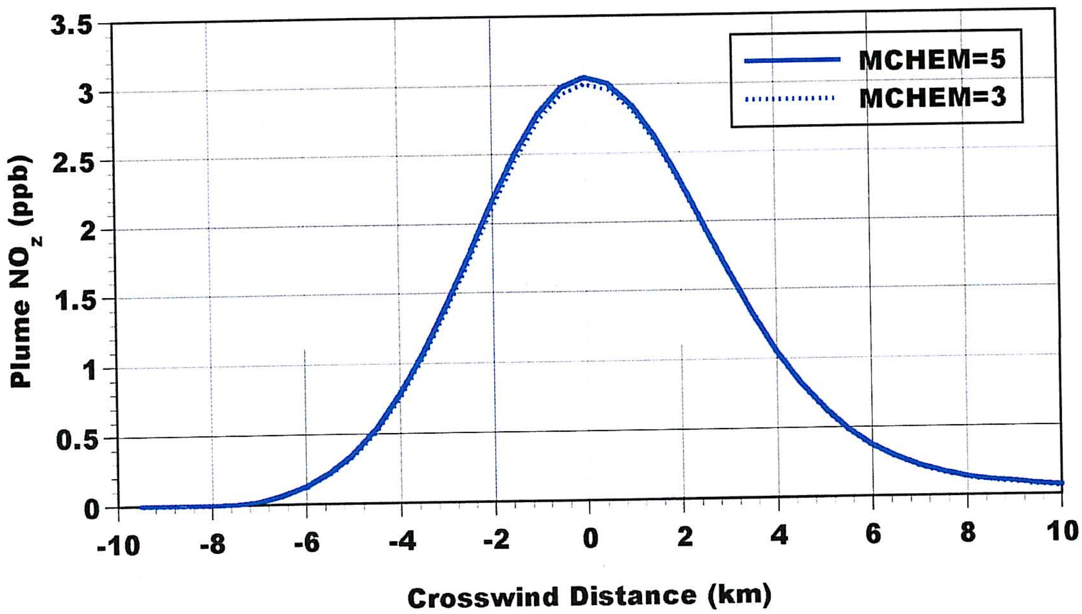
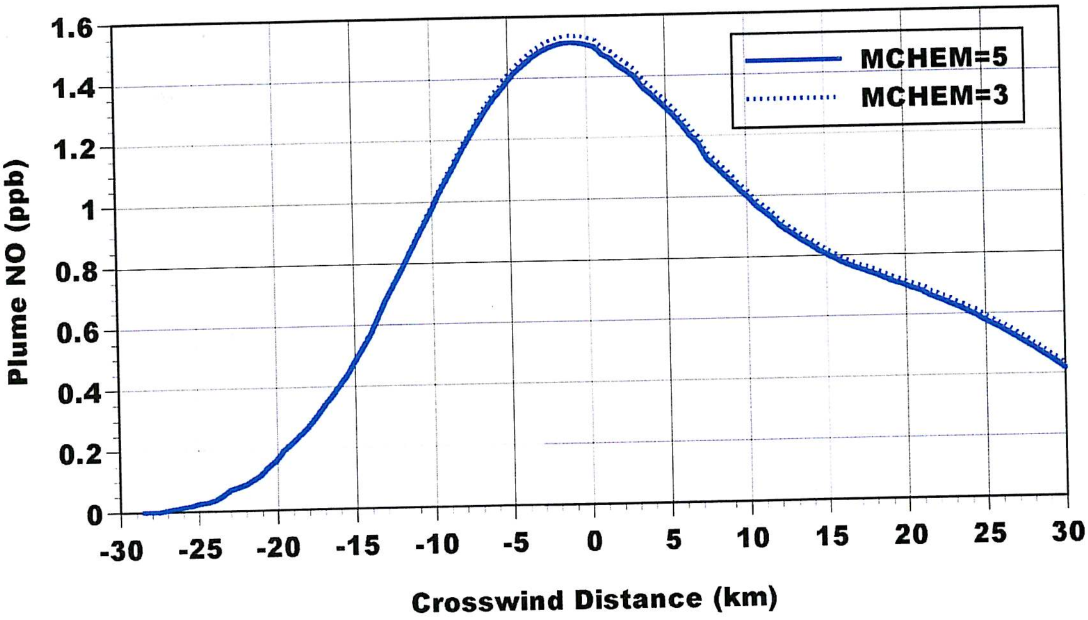


Figure 3-2. Sulfate and NO_z concentration profiles for plume traverse 187003. MCHEM=3 refers to the original CALPUFF RIVAD/ARM3 formulation, while MCHEM=5 refers to the corrected formulation.



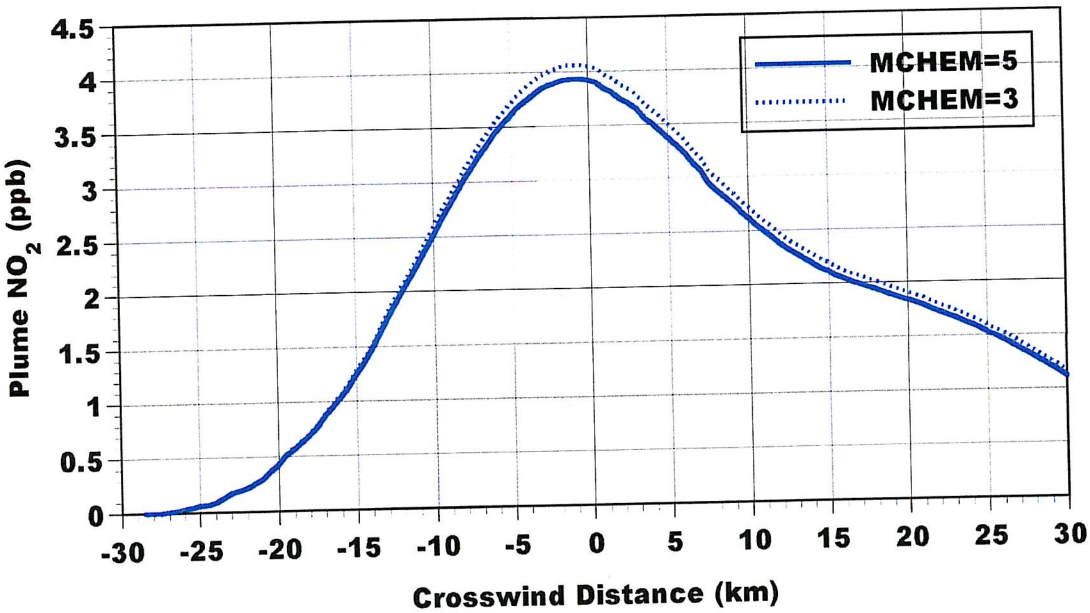


Figure 3-3. NO and NO_2 concentration profiles for plume traverse 187006. MCHEM=3 refers to the original CALPUFF RIVAD/ARM3 formulation, while MCHEM=5 refers to the corrected formulation.

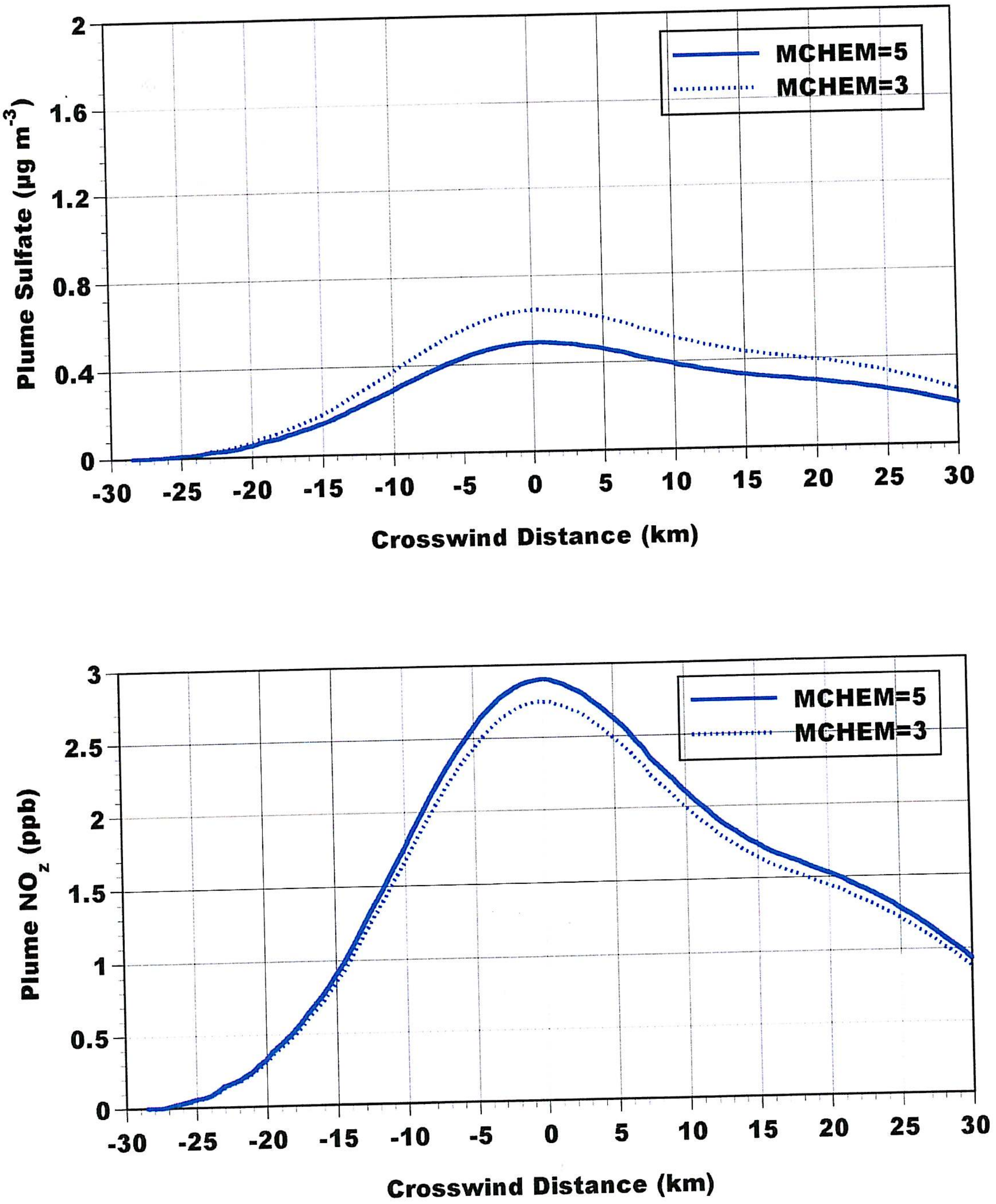


Figure 3-4. Sulfate and NO_z concentration profiles for plume traverse 187006. MCHEM=3 refers to the original CALPUFF RIVAD/ARM3 formulation, while MCHEM=5 refers to the corrected formulation.