ROSEMONT COPPER
redefining mining.

October 9, 2012

Mr. Jim Upchurch
Forest Supervisor
Coronado National Forest
300 West Congress
Tucson, Arizona 85701

Re: Response to August 20, 2012 Forest Service Letter

Dear Mr. Upchurch:

Along with this, please find a response written by JBR Environmental Consultants, Inc., our air-modeling contractor, to the issues raised in your letter dated August 20, 2012. The issues and questions raised in your letter were specifically answered in the JBR response and the models are currently running.

As I understand it, this is the current status of the modeling effort:

- AERMOD models are nearly complete,
- OZONE models are waiting on some of the NO_2 results,
- VISCREEN modeling is underway.

I understand the entire effort should be completed by about the end of October. JBR will provide interim results as they become final. If you have questions or would like to discuss any particular aspect of this letter or the attachments in greater detail, please let me know.

Regards,

Katherine Ann Arnold

Katherine Ann Arnold
Vice President, Environmental and Regulatory Affairs

Attachment: *JBR Response Letter*

Cc: Chris Garrett, SWCA

Doc. No. 063/12-15.3.1

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October 8, 2012

Mr. Jim Upchurch
Forest Supervisor
United States Department of Agriculture
Forest Service, Coronado National Forest
300 W. Congress
Tucson, AZ 85701

Dear Mr. Upchurch:

On behalf of Rosemont Copper Company (Rosemont), JBR Environmental Consultants (JBR) is providing this response to the Forest Service's letter dated August 20, 2012. As requested in the letter, this response has been developed in order to ensure that the information requested is clearly understood and in order to seek concurrence from the Forest Service (USFS) regarding some of the issues raised.

During JBR's and Rosemont's reviews of the Forest Service's letter, it became apparent that the revised modeling protocols ("AERMOD Modeling Protocol to Assess Ambient Air Quality Impacts", prepared by JBR, dated April 27, 2012; "CALPUFF Modeling Protocol to Assess Ambient Air Quality Impacts", prepared by JBR, dated May 15, 2012) had not been used as the bases for some of the comments provided. This is problematic since changes in the revised protocols were developed, in part, to respond to these same comments as previously presented. While the Forest Service's letter asks Rosemont to "insure that the information we have requested is clearly understood and that you have obtained concurrence from my office on the documentation requests," Rosemont also requests reciprocity in timely responses to prior requests and approval of the methods presented in this response.

Please note that the responses below provide new information, where applicable, regardless of the revised protocols submitted several months ago. Comments raised in the Forest Service's letter are addressed below.

1. ***The statistical analysis provided by JBR to exclude the highest monitored PM_{10} concentration of 71.3 µg/m^3 is insufficient justification for exclusion. Please explain why the highest monitored PM_{10} concentration of 71.3 µg/m^3 would be considered an outlier (i.e. mechanical error, other external reason not under control of Rosemont) or include the outlier in the modeling.***

The revised protocols dated April 27, 2012 and May 15, 2012 provide statistical analyses that were substantially revised from those included in the previous protocols. These analyses justify exclusion of the PM_{10} concentration of 71.3 µg/m^3. As shown in the revised analyses, the probability of occurrence of such an anomalous event is once in 127 years or once in 336 years, depending on the data set used for the probability analysis. The operating life for the Rosemont mine will be 20-25 years.

Comments to the Draft Environmental Impact Statement (DEIS) from Region 9 of the Environmental Protection Agency (EPA) dated February 21, 2012 stated, "In determining the 24-hour PM_{10} background concentration, EPA believes that while it may be appropriate to exclude the 71 $\mu g/m^3$ value on the basis that it appears to be a statistical outlier, additional justification should be provided in the EIS for doing so." The April and May 2012 revised modeling protocols provided extensive additional analysis justifying exclusion of this value. This information could easily be included in the final EIS, demonstrating that the necessary analysis has been performed. Indeed, even for the purpose of determining an area's compliance with the NAAQS, EPA states in Section 2.4 of Appendix K to 40 CFR Part 50 that "the use of statistical models or the use of historical data could be considered so that the event may be discounted or weighted according to the likelihood that it will recur." With a 1-in-127-years (or 1-in-336-years) frequency of occurrence, the weighting of this value should be minimal—or none.

Since the EIS is intended to "provide full and fair discussion of significant environmental impacts" per Title 40 of the Code of Federal Regulations (40 CFR) §1502.1, *Environmental Impact Statement – Purpose*, inclusion of an anomalous event that is not anticipated to recur within 100 years of the project's cessation cannot be considered either "reasonably foreseeable" or "significant" for the purpose of the EIS. Consequently, modeling will be conducted by replacing the 71.3 $\mu g/m^3$ PM_{10} concentration with the second high measured value of 40.3 $\mu g/m^3$ as suggested by EPA Region 9.

2. ***The use of annual average ozone was not appropriate as a substitution for missing data in the ozone data base. Please describe what ozone values were used for Tier 3 OLM NO_2 modeling technique. Tier 3 OLM being used by Rosemont for NO_2 modeling requires the use of hourly ozone data. For any missing data, the maximum hourly or conservative ozone value must be used.***

EPA guidance states that the modeled contribution to the cumulative ambient impact assessment for the 1-hour NO_2 standard should follow the form of the standard based on the 98th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled. A "first tier" assumption that may be applied without further justification is to add the overall highest hourly background NO_2 concentration from a representative monitor to the modeled design value, based on the form of the standard, for comparison to the NAAQS. Additional refinements to this "first tier" approach based on some level of temporal pairing of modeled and monitored values may be considered.

With regards to replacement of missing data, the monitoring period of interest is from March 2007 through February 2010 as this time interval represents 36 months of continuous meteorological data at the Rosemont site. Only 3% of the ozone data is missing during this three-year period. The longest period of consecutive missing hours occurred during November 2007 (November 11-15).

Replacement of this data will be in accordance with guidance from the Arizona Department of Environmental Quality (ADEQ). Per ADEQ's guidance, missing data will be replaced as follows: for missing data periods of a day or more in a month, each missing hour of monitored data will be replaced with the maximum ozone concentration for each corresponding diurnal hour of the month; for other missing hours, linear interpolation will be used to fill the missing concentrations. For missing data periods less than a day in duration, the longest missing data period to which linear interpolation is applied is six hours.

The month selected to determine a maximum concentration corresponds to the same calendar month considered over the three years of data. More specifically, data from November of 2007, 2008, and 2009 will be used to determine the maximum diurnal hourly values for replacement of the data missing from November 2007. This provides assurance that under similar meteorological conditions, a conservative impact will be calculated. The discussion in Attachment 1 elaborates on the procedure that will be applied to determine replacement values.

3. ***Documentation provided by Caterpillar provides only a range of in-stack NO_2/NO_x ratios from 0.05 to 0.15. Because there is no guarantee that said ratios will be at the low end of the range we are requiring that you disclose impacts at both the 0.10 and 0.05 levels (Scenarios 3 and 4).***

Caterpillar's documentation states that "engines certified for non-road use in the United States do not require a measurement split of NO_x emissions between NO and NO_2. Therefore, Caterpillar does not have this type of emissions data recorded." Caterpillar states further in that document that their estimated range for NO_2/NO_x of 5% to 15% is provided as a "general rule"; consequently, Caterpillar's documentation should not be used as the basis for determining NO_2/NOx ratios for haul trucks. While modeling will be performed at both 5% and 10% as the Forest Service is requiring, the available science and test results indicate that modeling an in-stack NO_2/NO_x ratio of 5% is remains conservative.

The Ozone Limiting Model (OLM) in AERMOD utilizes two variables to determine the predicted NO_2 concentration at each receptor: NO_2-primary and NO_2-secondary. Accurate representation of these variables is critical to obtaining accurate NO_2 modeling results. However, availability of quality data is limited. Prior to promulgation of the 1-hour NO_2 NAAQS in 2010, few sources encountered difficulty modeling compliance with the NO_2 standard. From 1971-2010, the primary and secondary NO_2 NAAQS were 53 parts per billion (ppb) on an annual basis as determined by the annual arithmetic average. The 2010 implementation of a 1-hour standard set at 100 ppb as determined by the 98th percentile monitored value, averaged over 3 years, introduced difficulties with modeling that had never been encountered for NO_2. These difficulties have been widely acknowledged by EPA[1].

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[1] See, for example, EPA's memos: June 28, 2010 entitled, "Applicability of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS" (http://www.epa.gov/ttn/scram/guidance/clarification/ClarificationMemo_AppendixW_Hourly-NO2-NAAQS_FINAL_06-28-2010.pdf); June 29, 2010 memo entitled, "Guidance Concerning the Implementation of the 1-hour NO2 NAAQS for the Prevention of Significant Deterioration Program" (http://www.epa.gov/nsr/documents/20100629no2guidance.pdf); March 1, 2011 entitled, "Additional Clarification Regarding Applicability of Appendix W Modeling Guidance for the 1-hour NO2 NAAQS" (http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf). Also see EPA's Technology Transfer Network (TTN) Support Center for Regulatory Atmospheric Modeling (SCRAM) NO_2/NO_x In-Stack Ratio (ISR) Database webpage at http://www.epa.gov/ttn/scram/no2_isr_database.htm.

Selecting representative in-stack NO_2/NO_x data is critical to the performance of OLM. OLM converts the total NO_x concentration, predicted at each receptor by AERMOD, to NO_2 according to the following equation:

$$[NO_2\text{-predicted}] = [NO_2\text{-primary}] + [NO_2\text{-secondary}]$$

NO_2-primary *is an estimate of in-stack* NO_2. The term "in-stack NO_2" means the portion of thermal NO_x gas that is *simultaneously converted* to NO_2 *and sampled* prior to its release from a stack. EPA test methods for diesel generator engines and mobile sources take measurements of NO_2/NO_x ratios at the stack exit. While these provide a better estimate of in-stack ratios than the highly unrealistic "default" values, some titration of NO_2 to NO_x has already occurred by the time the stack gases have reached the stack exit, resulting in ratios that are still higher than true in-stack NO_2/NO_x ratios. Additionally, the test methods themselves allow for some additional titration of NO_2 to NO_x, and even small amounts of conversion (i.e., ±1%) will skew the modeled results.

Samples acquired *in situ* from sources operating under normal conditions are ideal estimates of NO_2-primary for use in OLM. For haul trucks, sampling the engine-out gas stream from inside the tailpipe or exhaust manifold and at normal operating temperature would help to ensure that OLM performs as intended. Samples acquired or otherwise analyzed *ex situ*, such as from the sampling methods presented in 40 CFR Part 86 Subpart N or ISO 8178 and even open path measurements acquired by, for example, chase vehicles, are not well supported by OLM since they tend to overestimate the value of the primary-NO_2 variable. For example, samples of diluted engine exhaust that are stored in O2-prefilled bags and later analyzed tend to have excess NO_2 according to the equilibrium equation $NO + ½ O_2 <-> NO_2$; if excess oxygen is present as the gas cools, the reaction favors the right side as NO tends to be converted into NO_2. Overestimates from other sampling methods, such as fixed monitors or dilute gaseous exhaust sampling, are typically due to titration by ambient O_3 introduced into the sample based upon the equilibrium equation $NO + O_3 <-> NO_2$.

NO_2-secondary is an estimate of the remaining portion of NO_x as NO that will mix and convert to NO_2 by equal amounts of ambient O_3 during transport.

Modeling 1-hour NO_2 impacts from haul trucks using an in-stack primary-NO_2 ratio of 15% or even 10% is questionable because these values are arbitrary. Rosemont's proposal to model 1-hour NO_2 impacts using 5% in-stack NO_2/NOx is a conservative estimate of primary-NO_2.

According to laboratory data presented in a report by Diesel Controls Ltd. and the U.S. Bureau of Mines, titled "Nitrogen Oxides Reactions in Diesel Oxidation Catalyst" (Majewski et al., 1995, Attachment 2), it is estimated that approximately 0.3% of NO_x in diesel exhaust gas is NO_2 at 400ºC, based upon simultaneous *in situ* sampling of NO and NO_2. The maximum recorded ratio is approximately 3.0% at 200ºC. According to Caterpillar, the steady state exhaust stack gas temperature for the CAT® C175-16 Diesel Engine, which powers Rosemont's haul trucks, is approximately 446ºC. The 3% in-stack

NO_2/NO_x ratio is based upon the estimated maximum NO_2/NO_x data from the Majewski report provided in Attachment 2.

Rosemont proposes to model 1-hour NO_2 impacts from haul trucks using NO_2/NO_x ratios of 5%.

As required by the Forest Service, predicted impacts will be disclosed at NO_2/NO_x ratios of both 5% and 10%. Predicted impacts at a NO_2/NO_x ratio of 10%, however will be unrealistically high and not representative.

4. ***Concerns have been raised over the modeling for natural gas heaters. Please explain why natural gas field heater NO_2/NO_x ratio tested at 0.013 is acceptable and provide documentation of source test results to support the ratios tested.***

No natural gas heaters are proposed at Rosemont. A NO_2/NO_x ratio of 0.013 has not been proposed for any sources at Rosemont. The presentation provided in a previous submittal that referred to source test results for natural gas heaters was provided as additional documentation indicating that NO_2/NO_x ratios in the 0.05 range are both reasonable and conservative.

5. ***To insure that the representativeness and quality of air quality data provided is sufficient, additional information is needed. Please provide site logs from 2006 and 2007 for onsite meteorological monitoring and document why a data logger malfunction was not immediately detected and corrected. Provide documentation of corrective actions taken. Provide documentation of semi-annual instrument audits. Use a separate intact 3 year meteorological period (i.e. March 2007 to February 2010) rather than substituting missing data from the following year.***

Site logs have been provided to SWCA in a separate previous submittal, which is documented in Attachment 3. Copies of the site logs are being provided again in Attachment 3 for reference. Corrective actions taken are also included in this attachment and have been previously provided. The reason that the data logger malfunction was not immediately detected has not been identified. The semi-annual audits have been provided previously and due to their length, are not included in this submittal. Attachment 3 contains email documentation that these files have been previously received (see response from Bret Anderson dated July 26, 2012). In addition, several of these reports are available in the "Technical Reports" section under the heading "Air Quality" on the Forest Service's website for the Rosemont Copper Project's Environmental Impact Statement (http://www.rosemonteis.us/technical-reports/all).

As requested, the above-referenced meteorological data from the time period of March 2007 to February

2010 will be used in the modeling (see response to Comment 2 above).

6. ***Page 7 of the AERMOD protocol states "Background concentrations for the impact analysis at the Saguaro East NP were based on the (2007-2009) Aerosol data from the Saguaro East NP IMPROVE site. The 24-hr and annual average background $PM_{2.5}$ concentrations of 11.4 $\mu g/m^3$***

and 5.1 µg/m^3 respectively will be used." A review of the IMPROVE data shows that 24-hour and annual average background $PM_{2.5}$ should be 14.3 µg/m^3 and 5.06 µg/m^3, respectively. Please use these values as the background concentrations for the impact analysis in Saguaro National Park East or explain why the values suggested in the protocol should be used.

The above comment is based on the prior version of the modeling protocol. The revised AERMOD protocol submitted in April 2012 does not address background concentrations on page 7 as referenced above. In the revised AERMOD protocol, background concentrations are addressed beginning on page 16, and the discussion of the $PM_{2.5}$ background concentration begins on page 19. The revised AERMOD protocol states that background concentrations for Saguaro NP will be based on monitored data from 2008-2010 with the design value calculated pursuant to the procedure detailed in Appendix N to 40 CFR Part 50 and the March 23, 2010 EPA memo entitled, "Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS," which is being provided in Attachment 4.

On page 7 of the EPA memo on modeling procedures for the $PM_{2.5}$ NAAQS (Attachment 4), under the heading "*Comparison to the NAAQS,*" EPA describes the form of the representative monitored design value. For the 24-hour averaging period, the design value is based on the 3-year average of the 98th percentile 24-hour average $PM_{2.5}$ concentrations for the daily standard. This procedure was used to calculate the values in the previous protocol and will be used to calculate the value based on the 2008-2010 monitored data. The 24-hour and annual $PM_{2.5}$ background concentrations based on this procedure that will be used in the modeling analysis are 9.0 µg/m^3 and 4.24 µg/m^3, respectively.

The replacement values suggested in the Forest Service's comment above do not appear to have been determined according to the EPA methodology.

7. ***Numerous comments were received in regard to effects of lead dust on air quality. To allow us to evaluate these effects please determine the percent content of lead in mining and materials handling operations. Describe or model lead emissions to assure that compliance with the lead NAAQS standard will be achieved.***

Lead emissions will be quantified and modeled to address this comment.

CALPUFF

1. ***Employ the UAMAKE program to fill missing data periods, which extracts data from prognostic (e.g., MM5) data to create pseudo-soundings as replacements for missing upper air data. (Section 4.3).***

This change will be made as requested.

2. ***Use the August 31, 2009 EPA/OAQPS Model Clearinghouse Memorandum, not the IWAQM, to define parameter settings for CALMET input variables. The recommended setting for TERRAD in***

Table 4.1 is 10 km, not 15 km. Additionally, the protocol should provide model control option details that are used in the CALMET datasets to ensure consistency with FLM and EPA guidance. (Section 4.5)

The August 31, 2009 EPA/OAQPS memo will be used to define parameter settings for CALMET input variables. However, the recommended setting for TERRAD is not 10 km as cited above, but 15 km as shown in Table 4.1 of the revised CALPUFF protocol. Please see Attachment 5 to this letter for the relevant page from the August 31, 2009 EPA/OAQPS memo that provides the recommended TERRAD setting.

3. ***Update the protocol to address the following model control options (Section 5):***

   a) ***List which pollutants were modeled***

   b) ***Provide information regarding size distribution for PM in the deposition modeling***

   c) ***Elaborate on the switch settings utilized in the CALPUFF modeling to verify adherence to FLM guidance***

   d) ***Include sample input files as appendices (i.e., sample POSTUTIL file for both visibility and deposition, and a sample CALPOST file for visibility impacts at Saguaro West NP)***

   e) ***Follow EPA and FLM guidance regarding the technical options used in modeling (Section 5.2)***

A revised protocol will be submitted that incorporates the above information. Input files will also be provided to allow for a two-week period of review prior to conducting the modeling. Subsequent to the final modeling, all input, POSTUTIL, and CALPUFF files will be provided to document the model control options and parameters used.

4. ***As per FLM guidance, use hourly data for ozone concentrations instead of monthly averages. In the case of missing hourly data, for any missing data, a conservative monthly value can be substituted for the missing hourly value. (Section 5.3)***

Available hourly data will be used instead of monthly averages, as requested. Missing ozone data will be replaced as described in the above response to comment 2 to the AERMOD protocol. When hourly data is missing, one of two approaches will be used to replace the missing data. For missing data periods that last one day or longer in a particular month, the missing data will be replaced by the maximum ozone concentration recorded for each diurnal hour of the calendar month as observed throughout the three-year period of meteorological data. For other missing hours that last less than a day, linear interpolation will be used to fill the missing concentrations.

5. ***Confirm that the source characterization used in the AERMOD protocol (i.e., Road sources, truck unloading, sulfide ore stockpile, tailings stockpile, conveyor transfer points, gaseous emissions due***

to blasting, open pit, and tail pipe emissions) will also be applied in the CALPUFF analysis. Rosemont should provide the particulate speciation that identifies which sources will be emitting coarse particulate, fine particulate, and elemental carbon. (Section 6.2)

The release parameters and source characteristics in CALPUFF are identical to those used in the revised AERMOD protocol. Relative to the speciation of coarse, fine, and elemental particulate, emissions of each particle size are identified in the project emission inventory as PM_{10} and $PM_{2.5}$. All the emissions expressed as PM_{10} are considered to be PM-coarse. All the emissions expressed as $PM_{2.5}$ are considered to be PM-fine. The amount of elemental carbon in the vehicle $PM_{2.5}$ tailpipe emissions was provided in the project emissions inventory. However, elemental carbon has not previously been incorporated in the CALPOST calculation of light extinction; as a result, its use in CALPUFF is not directly related to modeled visibility impacts.

6. ***Provide detailed documentation of the calculations supporting the emission reductions claimed in discussions of the operational changes planned since prior submittals. (Section 7.1)***

The emission reductions are described in the revised AERMOD protocol dated April 27, 2012 as Appendix G.

AERMOD and CALPUFF

1. ***The protocol does not describe the near field visibility modeling analysis to assess visible plume impacts to Saguaro East NP. Please provide an addendum to the near field modeling protocol which includes a description of this information. The analysis should use the EPA VISCREEN model and should use the annual average visual range value for Saguaro NP from Table 10 in the FLAG guidance document. If the VISCREEN analysis shows visibility impacts beyond the limits described in the FLM's FLAG guidance document, a Level 3 visibility analysis with the EPA PLUVUE model will be required. If a Level 3 analysis is required, we request that Rosemont submit a separate modeling protocol for the PLUVUE analysis for review and concurrence. Also, please describe the modeling protocol for near-field AQRV (visibility and deposition).***

Over the course of developing the modeling protocols that were submitted, revised, and re-submitted, PLUVUE modeling was discussed and the cooperating agencies agreed it would not be required. Specifically, during the March 25, 2011 conference call involving the Forest Service and the Park Service, the direction to JBR for modeling was that PLUVUE would not be required. Arbitrarily imposing such a requirement at this time is unreasonable, and the previous discussion and agreement were based on the technical limitations of the visibility models for sources such as Rosemont.

Modeling using VISCREEN was conducted using higher emission rates than are currently proposed. In addition, the VISCREEN model is designed for point sources, whereas emissions from Rosemont are scattered throughout the pit and process area with haul truck emissions comprising greater than 80% of all emissions. There is no single stack to model, which is what both VISCREEN and PLUVUE are designed to do. Attempting to simulate numerous ground-level volume sources as a single-stack point source does not provide meaningful results. Use of a virtual distance to simulate emissions as a point source would result in placing the source at a distance of 107 km from the Saguaro National Park, which is outside the VISCREEN applicability range. This was the basis for the previous agreement to forego further analysis using VISCREEN or PLUVUE.

If VISCREEN indicates visibility impacts beyond the limits described in the FLM's FLAG guidance document, it is not a reasonable indicator of Rosemont's likely visibility impacts. Since VISCREEN and PLUVUE are single point source models, a vast number of generalizations have to be made to run the models for the numerous volume source such as those at Rosemont. The PLUVUE model is subject to the same limitations as VISCREEN and would also provide invalid results after very intensive modeling efforts.

Because previous modeling using VISCREEN was provided, and because emissions have subsequently been revised, VISCREEN modeling will be repeated using the revised inventory with the understanding that the predicted visual impacts are unrealistically conservative.

2. ***Guidance from EPA entitled "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" discusses intermittent sources such as emergency generators. This memo is specific to 1-hour NO_2. To make this case-by-case determination, please provide a rationale for why excluding the generator emissions is reasonable, given the projected operating schedule and the form of NAAQS being examined. Also provide written assurance that Rosemont will only run generators for periodic testing or when other equipment and processes are shut down.***

The provisions of 40 CFR Part 63 Subpart ZZZZ (Subpart ZZZZ) limit operations of emergency engines to no more than 100 hours per year for the purposes of maintenance checks and readiness testing and only when the tests are recommended by Federal, State or local government, the manufacturer, the vendor, or the insurance company associated with the engine (40 CFR §63.6640(f)(1)(ii)). Operation outside the required testing and maintenance or beyond 100 hours of non-emergency operation will result in the engine being re-classified under Subpart ZZZZ as a non-emergency engine and subject to additional requirements. Rosemont will operate the engines/generators only during maintenance and testing as allowed under Subpart ZZZZ, and during emergency situations during which other equipment and processes will be shut down.

In addition to NO_2 which is addressed by the EPA modeling guidance that the Forest Service referred to in its comment above, PM_{10} and SO_2 emissions from the emergency generators should be excluded from the modeling analysis based upon 40 CFR Part 51, Appendix W, paragraph 8.2.3(d). This provision allows for excluding emergency backup generators if the source can demonstrate that the generators will not operate simultaneously with the sources that they back up.

Emergency situations will result in the majority of emitting equipment not operating, resulting in overall reduced emissions, and the conditions surrounding such an emergency situation are not reasonably foreseeable. Peak PM_{10} concentrations from operations at Rosemont will occur during night and early morning conditions. Furthermore, Rosemont's quarterly testing of the generators will occur during daytime conditions when impacts are lowest. The testing frequency and timeframe of testing will thus occur when the emergency generators cannot cause or contribute to NAAQS exceedances under non-emergency scenarios. As a result, exclusion of the emergency generators from modeling is a reasonable approach.

In conclusion, the information provided above is intended to address the comments raised in the Forest Service's August 20, 2012 letter to Rosemont.

As a further comment, please also note that the AERMOD modeling grid for all previous modeling extended to 10 km for near-field evaluations and additional receptors were evaluated at the Saguaro East National Park. The 10 km near-field grid suffices to evaluate maximum impacts due to the Rosemont facility, as all emission sources are at or near ground level, and not from tall stacks from which thermal plume rise can result in significant impacts at remote distances. The adequacy of a 10 km grid has been demonstrated in the prior modeling analyses as evidenced by decreasing concentrations with increasing distance from the facility.

Modeling for larger receptor grids serves no purpose other than longer computer run times due to additional receptors (17,500 receptors for a 50 km grid versus 6,000 receptors for a 10 km grid). AERMOD modeling will thus proceed based upon the 10 km near-field receptor grid and the receptor grid for the Saguaro East National Park that is described in the April 27, 2012 AERMOD modeling protocol.

At this time, modeling will proceed as described above unless additional comments are provided in a timely fashion. Please call if you have any questions.

Sincerely,

Jamie Wilson, P.E.
JBR Environmental Consultants, Inc.

cc: Kathy Arnold, Rosemont Copper Company

ATTACHMENT 1

Response from the Arizona Department of Environmental Quality (ADEQ) Regarding Missing Background Ozone Data

From:	Balaji Vaidyanathan [Vaidyanathan.Balaji@azdeq.gov]
Sent:	Friday, May 18, 2012 10:20 AM
To:	Louis Thanukos; Shantanu Kongara; Jamie Wilson
Cc:	Kathy Arnold; Eric Hiser; Feng Mao; Michael Sundblom
Subject:	Rosemont Modeling
Attachments:	Rosemont Modeling Issues.doc

Louis,

Attached, please find ADEQ's position on the unresolved modeling issues. Please take a look and let us know how you would like to proceed.

Thanks,
Balaji

Rosemont used the Tier 3 OLM approach for estimating the 1-hour NO_2 impacts from the proposed sources. There are two key model inputs under Tier 3 Options for the NO-to-NO2 conversion, namely background ozone concentrations and in-stack ratios of NO_2/NOx emissions. At the meeting dated March 20, 2012, ADEQ and JBR (the consultant for Rosemont) have initially discussed the selection of the ozone monitoring site, the methodology for filling in missing hourly ozone data, and the use of representative in-stack ratios for varied sources. The following additional discussions attempt to clarify the department's status regarding the two critical issues.

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1. Ozone Data

Selection of Ozone Monitoring Site

JBR selected the Chiricahua National Monument, a "regional" site, for the ozone background data because "it is more representative of the Rosemont site due to similar terrain features, elevation, and remoteness from emission sources". In general, a "regional" site may be used only if there are no monitors located in the vicinity of the source (Appendix W Section 8.2.2). Moreover, it is not clear whether the surrounding area of Rosemont is free from the impacts of the sources within the Tucson Metro area, possibly due to the transport of ozone and its precursors.

The monitoring site nearest to Rosemont is Green Valley (AQS Site ID: 04-019-1030), which is located around 15 miles to the west of the project site. ADEQ has reviewed the monitoring data collected from both the Green Valley site and the Chiricahua site, and compared the two datasets with the same sampling period (Years 2006-2008). The results are shown in Figure 1. As indicated in Figure 1, the hourly maximum concentrations of the Chiricahua site are comparable or higher than that of the Green Valley site. Therefore, from the perspective of modeling, the use of the Chiricahua data may relatively overestimate the conversion of NO to NO_2 and thus provide a relative conservative estimation for the 1-hour NO_2 impacts from the proposed sources.

Based on the discussion above, ADEQ approves the use of Chiricahua data for hourly background ozone levels.

Methodology for Filling in Missing Hourly Ozone Data

As discussed in the letter from ADEQ to Rosemont dated Feb.29, 2012, ADEQ disagrees with the substitution for missing hourly ozone data by using annual average concentration, since the use of the annual average concentration may underestimate the ozone concentration for the missing hours, leading to the underestimation of the conversion of NO to NO_2. To be defensible, the potential maximum ozone concentrations for these specific missing hours should be estimated and input to the model.

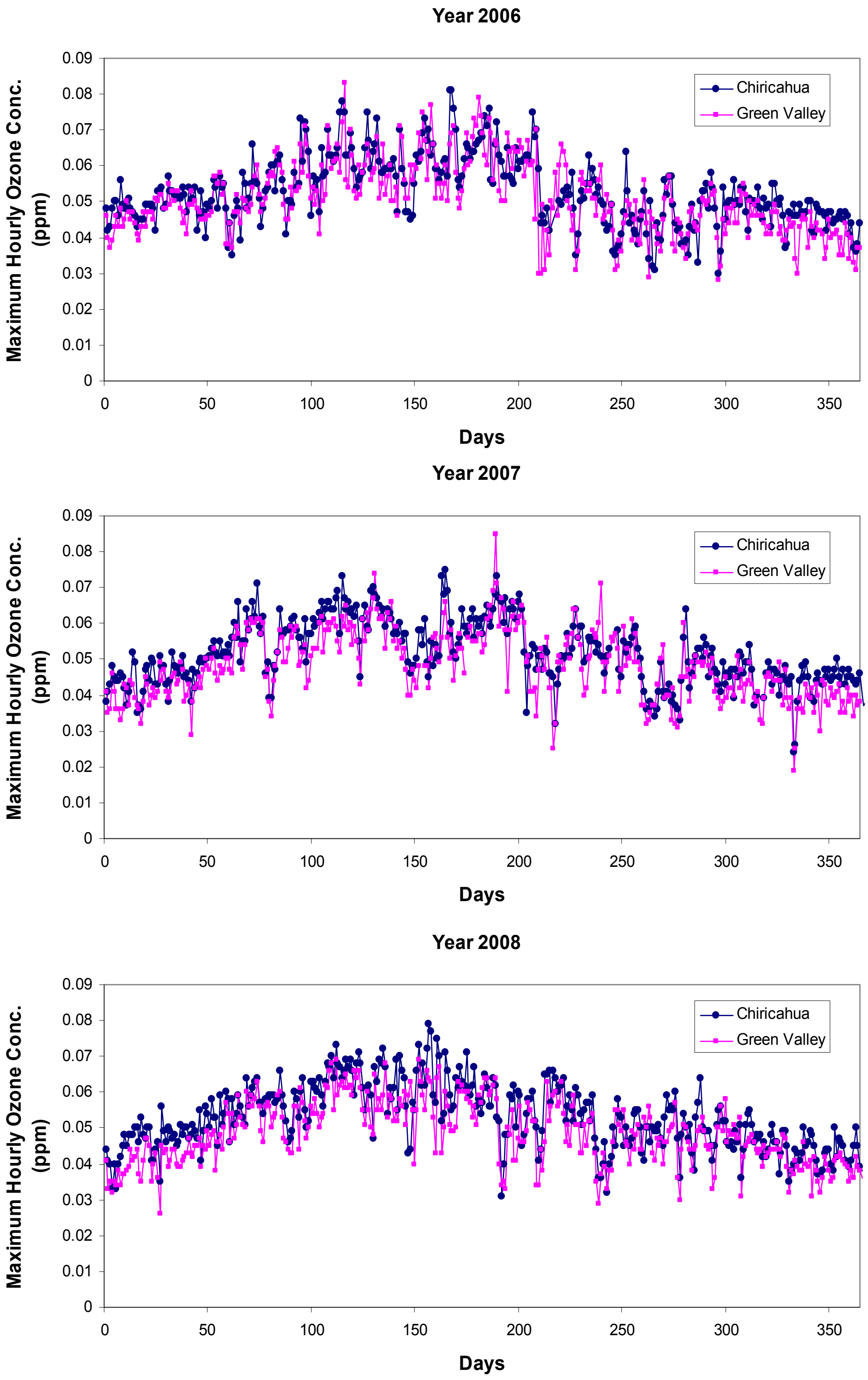

Figure 1 Hourly Maximum Ozone Concentrations for Chiricahua and Green Valley Sites

According to the hourly ozone data file JBR provided (OLM.csv), about 4 percent hourly ozone data were missing during the modeled period (April 1, 2006-March 31, 2009). In a typical data missing event, only a few consecutive hours of ambient ozone concentrations were missing. However, significant missing data periods (about 4-5 days) occurred at the Chiricahua site in August 2006 and November 2007. To estimate hourly ozone concentrations for these consecutive missing days, ADEQ has reviewed hourly ozone data collected in the months of August and November for Years 2006-2008. A statistical analysis was performed to summarize the ozone concentration for each diurnal hour. The results are shown in Figure 2. As presented, the ozone concentrations for each diurnal hour vary significantly under the same month, although the medium values show a typical ozone diurnal pattern. Apparently, it is a challenge to realistically estimate the missing hourly ozone data for these consecutive days.

ADEQ recommends the following procedures for filling in missing hourly ozone data:

- For the missing data period of August 3-8, 2006, use the maximum ozone concentrations for each diurnal hour that are determined based on the measurements in August (see the table below);
- For the missing data period of November 11-15, 2007, use the maximum ozone concentrations for each diurnal hour that are determined based on the measurements in November (see the table below);
- For other missing hours, use linear interpolations to fill in the missing concentrations based on the previous and subsequent hour concentrations or simply use the higher one.

Hour	Ozone in August (ppb)	Ozone in November (ppb)
1	63	55
2	57	54
3	60	53
4	50	52
5	60	52
6	54	51
7	53	51
8	52	50
9	61	51
10	60	52
11	65	54
12	64	55
13	64	53
14	64	53
15	65	54
16	65	54
17	66	54
18	66	54
19	64	51
20	58	52
21	56	54
22	60	55
23	58	55
24	55	55

If JBR would like to propose an alternative approach for the data substitution, please provide sufficient justification for the approach to be used.

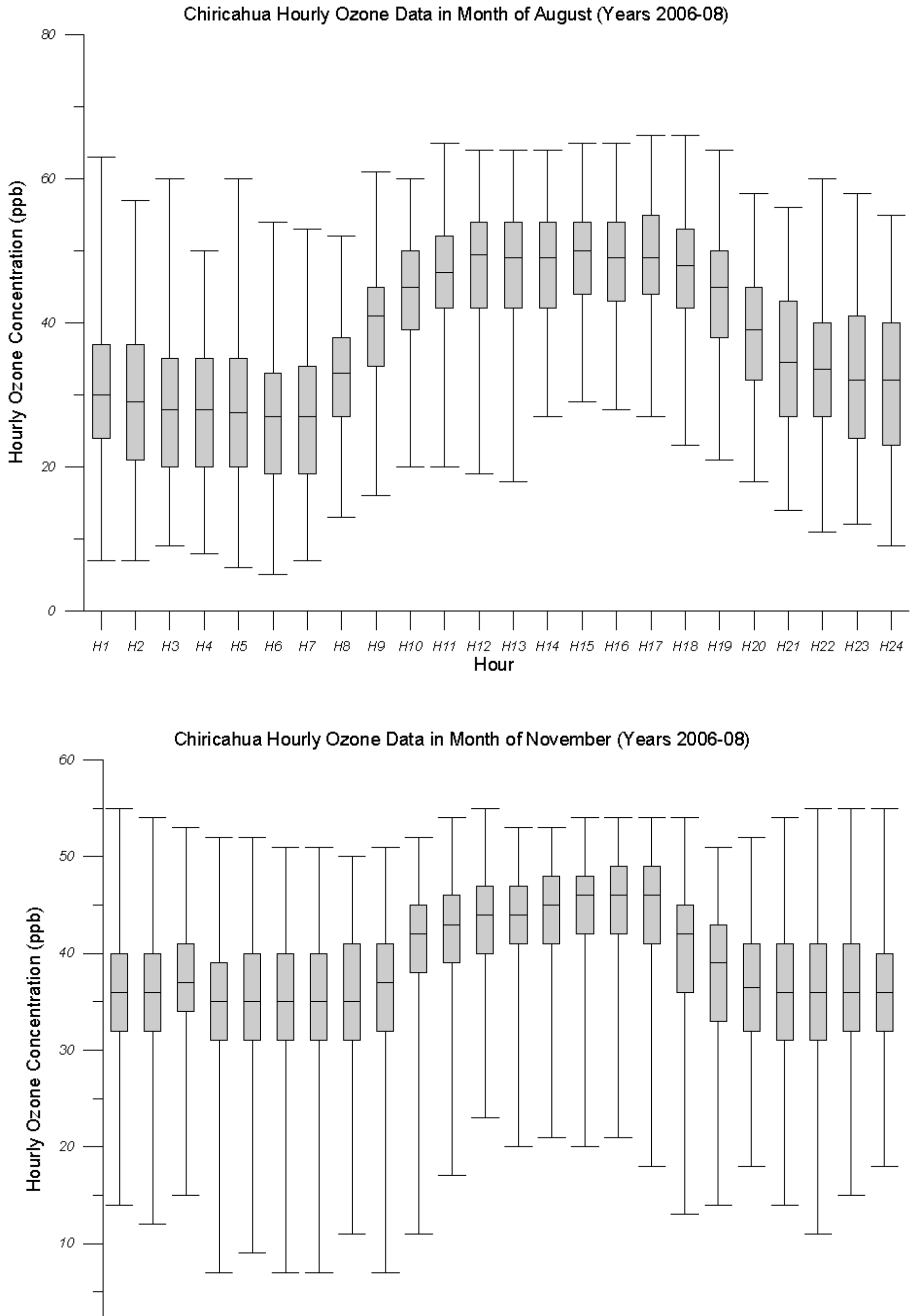

Figure 2 Chiricahua Hourly Ozone Concentrations in Months of August and November

2. In-stack ratios of NO_2/NOx emissions

In the letter from ADEQ to Rosemont dated Feb.29, 2012, ADEQ requested additional justification for using an in-stack ratio of 0.05 for emissions from natural gas-fired heaters as well as the blasting. At the meeting dated March 20, 2012, JBR provided some actual in-stack measurements for gas-fired heaters and justified that a ratio of 0.05 was relatively conservative than the testing data. Regarding the blasting sources, JBR argued that the contribution of the blasting sources to the modeled impacts was insignificant. However, this argument did not provide justification why a ratio of 0.05 was appropriate for modeling the blasting sources. Since no comparable test data exist for blasting emissions, the use of a ratio of 0.05 was arbitrarily and the modeling methodology was not defensible.

In the EPA's memorandum dated on March 1, 2011, a default in-stack ratio of 0.5 is recommended in absence of more appropriate source specific information in a Tier 3 PVMRM/OLM analysis:

> *"We recommend ...0.50 as a default in-stack ratio of NO2/NOx for input to the PVMRM and OLM options within AERMOD, in the absence of more appropriate source-specific information on in-stack ratios."*

Due to the absence of source-specific in-stack ratios, ADEQ recommends a default in-stack ratio of 0.5 for modeling blasting sources.

ATTACHMENT 2

Majewski, W.A., et.al.

Nitrogen Oxides Reactions in Diesel Oxidation Catalyst

SAE TECHNICAL PAPER SERIES

950374

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Nitrogen Oxides Reactions in Diesel Oxidation Catalyst

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U.S. Bureau of Mines

ABSTRACT

Two catalyst formulations were tested on a diesel engine. A Fourier Transform Infrared (FTIR) analyzer was used to measure concentrations of nitric oxide (NO) and nitrogen dioxide (NO_2). Other exhaust gas components were measured by conventional analyzers.

The results indicate that nitrogen oxides (NO_x) undergo complex chemical reactions in the diesel oxidation catalyst (DOC). The increase of NO_2 occurring at a certain temperature range is accompanied by a decrease of the total NO_x emission. NO_2 is probably an important itermediate product in the lean NO_x catalyst reaction chain.

INTRODUCTION

Catalytic reduction of NO_x under lean conditions became the research focus for both diesel and automotive applications. Surprisingly, very little data is published on the role of NO_2 in the nitrogen oxides catalysis. Majority of experimental work is limited to the total NO_x measurements only and attempts are made to interpret the results in terms of NO reactions. On the other hand, it is a known fact that precious metal catalysts can oxidize NO to NO_2 in diesel exhaust *[9,10]*. As a result a significant fraction of NO_x may be present as NO_2. Because NO_2 exhibits high chemical activity, it may deserve more attention in the NO_x catalysis models.

From the underground mining perspective the oxidation of nitric oxide to nitrogen dioxide may be a counterproductive process. Occupational Health and Safety standards legislating the ambient air quality regulate each nitrogen oxide separately. Exposure limits of NO_2 are about ten times lower than those for NO. The Mine Safety and Health Administration has proposed permissible exposure limits of 3 ppm for NO_2 and 25 ppm for NO for mines in the U.S.*[8]*.

The purpose of this paper was to study the influence of different catalyst formulations and engine conditions on the transformations of NO_x and generation of NO_2 in diesel exhaust gas. To interpret the experimental data a discussion of several possible nitrogen oxides reactions was necessary. Some of the reactions are those occurring in the "lean NO_x catalyst".

Investigation of nitrogen oxides reactions has been made possible with the introduction of high accuracy exhaust gas analyzers. Effects of DOCs upon nitrogen oxides emission were researched by means of a Fourier Transform Infrared instrument. The experimental part has been performed at the USBM's Diesel Emissions Research Laboratory. Catalyst samples were tested on a diesel engine over a slow engine load ramp with temperatures increasing from 150 to 550 °C. Nitrogen oxides, sulfur dioxide, carbon monoxide and hydrocarbons were measured at the inlet and outlet of each catalyst.

Two catalyst samples were investigated: a platinum and a palladium based formulation. The samples were prepared for this study by Diesel Controls Limited.

EXPERIMENTAL METHODS

APPARATUS - All testing was conducted in the USBM's Diesel Emissions Research Laboratory (DERL). A schematic of its sampling system is shown in Fig.1. A brief description of the apparatus used during this testing is given below and described in more detail elsewhere *[1-4]*.

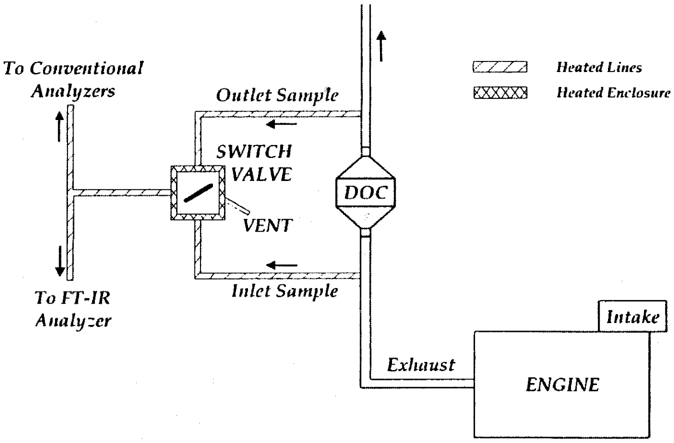

Figure 1. Laboratory Flow Schematic

TEST ENGINE - The evaluations reported here were made by installing DOCs in the exhaust stream of a 7-liter, pre-chamber, naturally aspirated, Caterpillar 3304 mining diesel engine. For standard U.S. Mine Safety and Health Administration (MSHA) test conditions, the maximum power rating of this engine is 75 kW (100 hp) at 37 Hz (2200 rpm).

During the evaluations, the engine's intake air was controlled to SAE standard conditions of 100 kPa (402 "H_2O) and 25°C (77°F).

The fuel used throughout all of the testing was commercially available, low-sulfur (<0.05%) fuel, and conforms to the 1993 U.S. Environmental Protection Agency (EPA) regulation for diesel fuels *[5]*.

GASEOUS EMISSIONS SAMPLING SYSTEM - Emissions of carbon monoxide and carbon dioxide were measured using a Pierburg BINOS-2000 non dispersive infrared analyzer, while gaseous hydrocarbons were measured using a Pierburg FID PM-2000 flame ionization analyzer. A Rosemount 880 nondispersive infra-red analyzer was used to measure SO_2 emissions, and an Oxymat PM-2000 paramagnetic analyzer was used to measure O_2.

A Nicolet Rega 7000 FTIR Spectrometer exhaust gas analyzer *[6,7]* was used to measure the NO and NO_2 emissions during these tests. Unlike the conventional analyzers, the FTIR analyzer is able to measure the exhaust concentrations of both NO and NO_2 directly, concurrently, and in the same sample. Since there is no full scale or "ranges" on the FTIR, the accuracy is based on the calibration gas used. In this case, the accuracy of the NO measurement was ±15 ppm, and NO_2 was ±2 ppm.

Continuous samples of gas-phase emissions were taken via an exhaust flow-switching configuration consisting of a heated enclosure (containing flow-switching valves) and three heated sample lines as illustrated in Fig.1. Using this sampling system, it was possible to sample the gaseous emissions alternately from the engine exhaust upstream of the DOC, and from the exhaust downstream of the DOC, without stopping the engine to insert or remove the DOC. This is accomplished by a set of valves which divert the sample to heated lines which convey the samples to the traditional and FTIR exhaust gas analyzers. A vent line is used to maintain constant flow conditions in the upstream and downstream sample lines regardless of which sample arm is being used.

Several other species can be included in the FTIR measuring program. Other nitrogen compounds measured in this study by FTIR and mentioned in the further discussion were ammonia and nitrous oxide.

ENGINE OPERATING CONDITIONS

Chemical reactions, such as oxidation, tend to occur more rapidly at higher temperatures. The temperature of diesel exhaust depends upon engine load, so that the performance of a DOC depends critically upon the engine used and its duty cycle as well as the location of the DOC with respect to the exhaust manifold. For this reason, it is important to evaluate aftertreatment devices over a range of exhaust temperatures. "Ramp" tests are conducted to screen aftertreatment devices. The test is performed at a constant engine speed of 1500 rpm. Emissions are measured while increasing the engine load from 27 N·m (20 lb-ft) to 325 N·m (240 lb-ft) at a very slow rate: 0.019 N·m/s (5/6 lb-ft/min). The corresponding rate of change of temperature of the DOC is about 0.025°C/s (2.7°F/min). Fig.2 shows the actual progress of torque and exhaust temperature during a typical ramp. One ramp test was conducted on each DOC. The results from these tests were similar to the results from ramp tests previously conducted on other DOCs *[9]*.

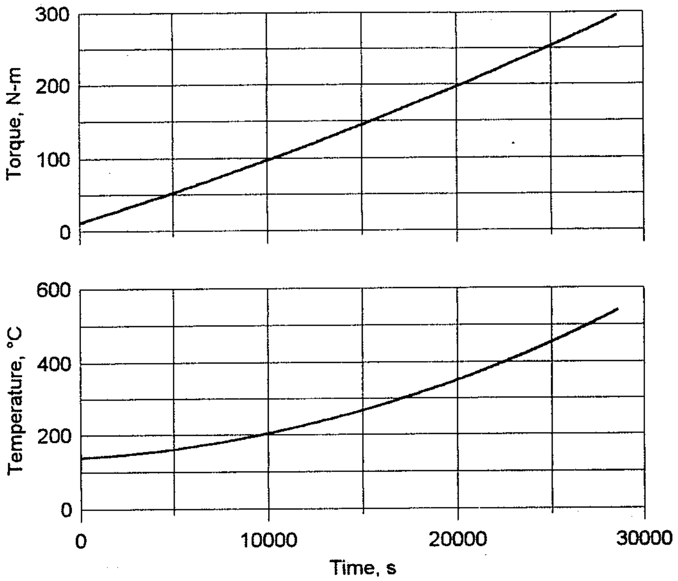

Figure 2. Temperature and Engine Load During a Ramp Evaluation

Fig.3 illustrates the concentration of CO measured as a function of exhaust temperature. Gas concentration measurements are taken every 20 seconds yielding the total of about 1400 measuring points during one ramp test. The sampling location is alternated every 10 minutes.

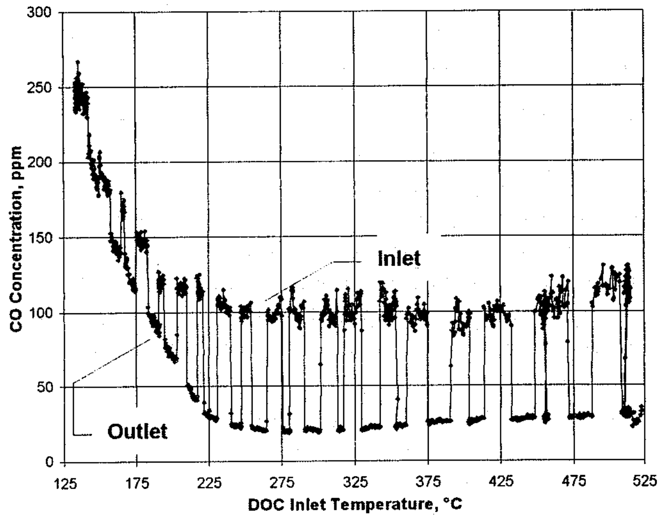

Figure 3. Carbon Monoxide Sampling During a Ramp Test Illustrating Inlet/Outlet Switching

Interpolation gives an excellent indication of what the measured concentrations are throughout the entire sampling period. Note that beyond 140°C (284° F) the concentration of CO is less downstream (Outlet) than upstream (Inlet), reflecting the oxidation of CO by the DOC. At higher temperatures more than 75% of the CO is removed. The purpose of this illustration is to convey the general idea of determining the influence of the DOC upon emissions through the use of the switching method described. The situations to be discussed further involve NO_2 and NO and are somewhat more complex so that it is helpful to keep the overall technique in mind.

Graphs used in the further discussion are curve fitted representations of experimental data.

CATALYTIC CONVERTERS

Two catalytic converters were tested. Both of them had the same γ-alumina washcoat but different precious metals formulation. Some data on both units are listed in Table 1.

Table 1
Technical Data on the Catalytic Converters

	Pt Catalyst	Pd Catalyst
Substrate type	Metallic	
Diameter, mm	149.2	
Length, mm	90	
Volume, dm^3	1.578	
Cell density, cm^{-2}	30	
Washcoat	γ-Al_2O_3	
W/c loading, g/dm^3	100	
Precious metal	Platinum	Palladium
Metal loading, g/dm^3	1.4	2.1

Both catalysts were tested at the constant engine speed of 1500 rpm. The resulting exhaust gas space velocity in each catalyst was approximately constant and amounted to 165000 Sm^3/m^{3}h.

Both units underwent the following, 2-step, preconditioning cycle prior to tests:

(1) 240 minutes long diesel engine preaging at 200°C with 5-minute long, 400°C temperature peaks every 30 min. High sulfur fuel (approx. 0.3% S) was used for the engine preaging.

(2) 60 minute oven heat treatment at 500°C in air atmosphere.

CATALYST PERFORMANCE: CO, HC AND SO_2

The two catalyst formulations differed significantly in their oxidation activity. Results pertaining to the oxidation of carbon monoxide, gas phase hydrocarbons and sulfur dioxide are plotted as concentrations in Fig.4. The top left plot - carbon monoxide on the platinum catalyst - represents exactly the same set of data which was already shown in Fig.3. The same data is plotted in terms of conversions in Fig.5.

High conversions of hydrocarbons and CO are very desirable performance characteristics of the diesel catalyst. High conversion of sulfur dioxide leads to the generation of sulfuric acid and an increase in particulate emission what is commonly perceived as a negative effect. Because of the Environmental Protection Agency's diesel particulate regulations, low sulfate formation became a target for the design of diesel catalyst formulation.

The platinum formulation (Fig.4 and 5 left) exhibited both good conversions and low light-off temperatures in respect to carbon monoxide and hydrocarbons. Unfortunately, the SO_2 conversion was also high, especially at higher temperatures. The palladium catalyst (Fig.4 and 5 right) features virtually no activity for the SO_2 oxidation. The penalty is a significantly higher light-off temperature for both carbon monoxide and hydrocarbons.

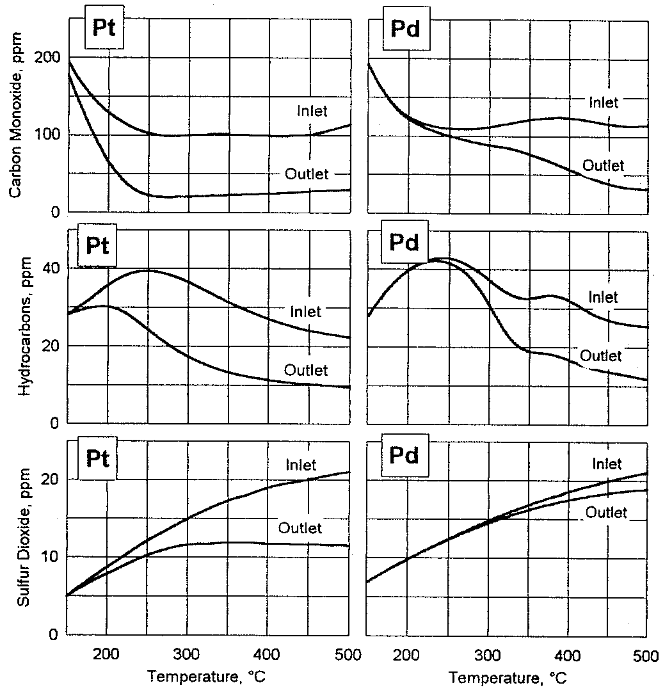

Figure 4. Concentrations of Carbon Monoxide, Hydrocarbons and Sulfur Dioxide on Pt and Pd Catalyst

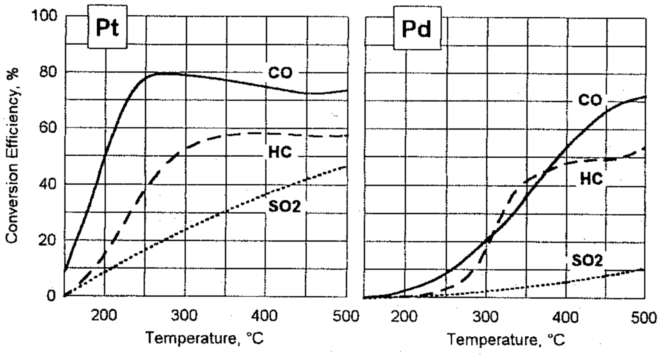

Figure 5. Conversions of Carbon Monoxide, Hydrocarbons and Sulfur Dioxide on Pt and Pd Catalyst

An interesting feature visible in the conversion graph (Fig.5) is the maximum conversion of carbon monoxide on the Pt catalyst, taking place at 275°C. Also the hydrocarbons conversion shows a maximum, although less pronounced, at about 375°C. Conversions of all species on the palladium catalyst continuously increase with temperature and do not exhibit a maximum.

CATALYST PERFORMANCE: NITROGEN OXIDES

Inlet and outlet concentrations of nitric oxide and nitrogen dioxide as a function of the DOC inlet temperature during the ramp test are shown in Fig.6. Plots on the left and right side represent results on the platinum and palladium catalysts, respectively. The top graphs display NO concentrations. The bottom graphs depict NO_2 data.

The platinum catalyst promotes the oxidation of nitric oxide to nitrogen dioxide accordingly to reaction Eq.(1):

$$NO + \frac{1}{2} O_2 \leftrightarrow NO_2 \qquad (1)$$

The equilibrium concentration of NO based on this reaction under the conditions present in the exhaust is also plotted in Fig.6. The process described by Eq.1 has already been the subject of previous studies *[9,10]*. The NO oxidation was confirmed in this work and is visible in the Pt plots (Fig.6) at temperatures of 250°C and higher. NO concentration decreases at the outlet from the DOC and the NO_2 concentration increases at corresponding temperatures. Conversion of NO reaches a maximum at 360°C. A peak NO_2 concentration at this temperature occurs (lower graph). Concentrations of NO (upper graph) at the DOC outlet are significantly lower than those at the DOC inlet with the maximum difference occurring at about 380°C.

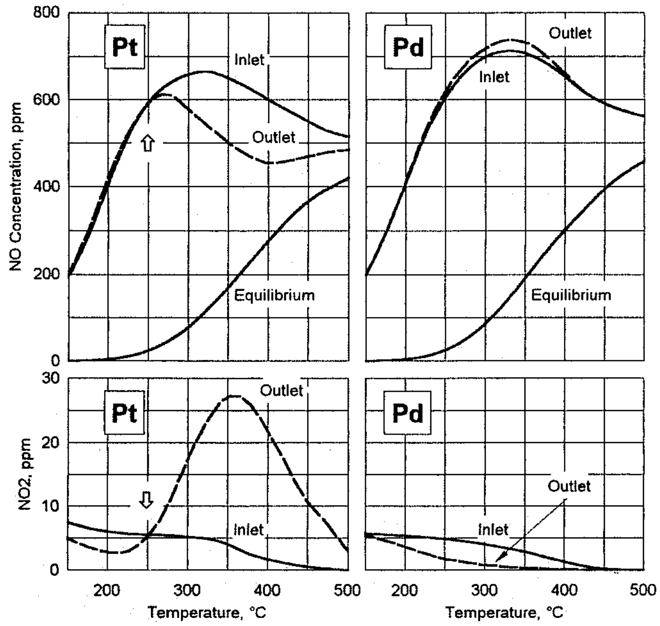

Figure 6. Nitrogen Oxides Concentration

At temperatures higher than 360-380°C the NO oxidation rate slows down. Less difference between the inlet and outlet NO concentrations is observed and the NO_2 concentration at the DOC outlet decreases. It is believed that this behavior is the result of thermodynamic limitations. Reaction Eq.(1) is an equilibrium reaction. A double-head arrow has been used in Eq.(1) to indicate that NO will not react completely with oxygen to form NO_2. Rather, an equilibrium composition can be reached where the system becomes thermodynamically stable. In such an equilibrium product mixture the reaction will not proceed any further. Concentrations of reactants in the equilibrium state are correlated by the reaction equilibrium constant K_p. The equilibrium constant can be calculated from thermochemical properties of reactants. It depends on temperature and therefore the calculations must be done for several temperatures within a given range. The exact thermodynamic formulas are given in the section Theoretical Considerations, Eq.(14)-(16).

Such thermodynamic calculations have been performed for reaction Eq.(1). The equilibrium constant was calculated for temperatures from 150 to 500°C. Then, the NO equilibrium concentration was calculated and plotted in Fig.6 (upper graph). The inlet concentrations of species were assumed for the calculations. Oxygen concentration in the exhaust gas during tests changed from approximately 17% at 150°C to 7% at 500°C.

The equilibrium line runs below the NO inlet line indicating that the reaction will progress to the right side of Eq.(1). The meaning of the equilibrium curve is that NO will decrease from the *inlet* concentration to the *equilibrium* concentration, in the result of a spontaneous progress of the reaction Eq.(1). At low temperatures, below 200°C, the equilibrium concentration of NO equals practically zero. The reaction can continue until almost the whole amount of nitric oxide present in the system is oxidized to nitrogen dioxide. At higher temperatures the equilibrium concentration of NO increases. When the exhaust temperature approaches 500°C, the inlet and equilibrium curves approach each other and the extent of the reaction progress is seriously limited.

It should be stressed that thermodynamic constraints are in no relation whatsoever to the reaction kinetics. Equilibrium can be perceived as a state that would be reached between reagents in a closed system after an infinitely long time elapsed. Thus, if thermodynamics prevents certain processes from proceeding they cannot occur. However, even if a reaction is feasible from the equilibrium point of view, it may not be fast enough to be completed within a reasonable period of time. It is the function of a catalyst to accelerate slow reactions.

Interesting concentration profiles have been measured on the platinum catalyst at low temperatures. Inlet and outlet curves for both NO and NO_2 cross each other at approximately 250°C. Points of crossing are indicated by vertical arrows in Fig.6. At low temperature the nitric oxide concentration at the outlet from the catalyst is *higher* than that at the inlet. The difference is small and hardly visible in Fig.6. The pertinent section of the curve appears to be just a thicker line. In fact, the outlet curve runs above the inlet one. Altogether, the platinum catalyst generates nitric oxide below 250°C. A similar cross-over of inlet and outlet concentrations happens to nitrogen dioxide. NO_2 outlet concentration at temperatures below 250°C is lower than its inlet concentration indicating an overall reduction occurring in the DOC.

The palladium catalyst results (Fig.6 right) follow the low temperature platinum pattern throughout the tested temperature range. The catalyst generates small amounts of nitric oxide at temperatures between 200 and 425°C. Nitrogen dioxide is reduced in the catalyst within the whole temperature range.

Equilibrium curve for NO oxidation was also calculated and plotted for the Pd catalyst test. The small differences between equilibrium concentrations in both tests are due to slightly different engine baselines (inlet concentrations). Equilibrium curves run *below* the actual concentrations. Consequently, the progress of reaction Eq.(1) must be to the right side of the equation, i.e. NO_2 is generated and NO is consumed in the process. The opposite tendency which was observed on the Pd catalyst as well as on the Pt catalyst at low temperatures indicates that nitrogen oxides chemistry in the diesel catalyst is not limited to the simple oxidation of NO, Eq.(1). Nitrogen oxides must undergo other than Eq.(1), concurrent reactions.

BALANCE OF NITROGEN OXIDES

The stoichiometry of the oxidation of nitric oxide is given by Eq.(1). One mole of NO reacts with oxygen to produce one mole of NO_2. Under the conditions in diesel exhaust one mole of NO takes the same volume as one mole of NO_2. Consequently, with the reaction progress, an increase of NO_2 concentration by 1 ppm should be accompanied by a decrease of NO concentration of exactly 1 ppm. Total NO_x concentration should not be affected by the transformation of NO into NO_2.

Fig.7 illustrates the nitrogen oxides balance as measured during ramp tests on both catalysts. The same scale is applied for both the Pt and Pd units to emphasize the difference in performance. The top graphs represent changes in NO and NO_2 concentrations as the gas passes through catalysts. The most striking realization is the lack of balance between NO and NO_2 on the Pt catalyst. At temperatures between 350°C and 400°C approximately 20 to 25 ppm of NO_2 is generated. This is accompanied by a disappearance of more than 150 ppm of NO. For each mole of NO_2 generated about seven moles of NO disappear from the system. This ratio between NO_2 generated and NO disappearing from the system was constant at all temperatures where the reduction of NO was taking place. A net reduction of NO_x takes place which is illustrated in the bottom graph in Fig.7. The Pt catalyst is a net NO_x remover at temperatures of 250°C and higher with the maximum conversion efficiency of 22% at about 380°C.

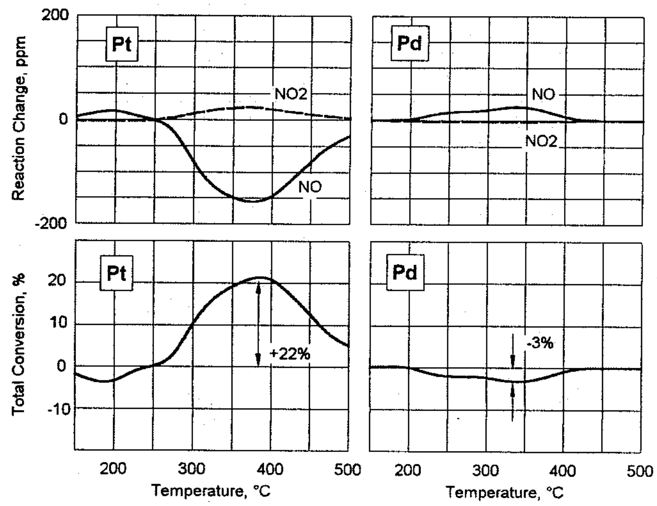

Figure 7. Nitrogen Oxides Balance

The platinum catalyst, as already discussed, shows a reversed performance tendency at low temperatures. NO_2 is removed from the system and NO is generated. The same kind of behaviour is displayed by the Pd catalyst through most of the whole temperature range. The amount of NO generated is bigger than that of NO_2 removed, contributing to a net NO_x generation. The Pd device generates up to 25 ppm of NO (between 200 and 425°C), removing about 3 ppm of NO_2 (all temperatures). There is no constant ratio of NO generated to NO_2 removed. The mechanism of NO generation, although interesting theoretically, is of no practical importance, as the maximum total NO_x generation (negative conversion) on the Pd catalyst amounts to 3% (Fig.7 bottom).

THEORETICAL CONSIDERATIONS

There are many potential reactions of nitrogen oxides in diesel exhaust. Nitrogen compounds present in exhaust gases from internal combustion engines include, beside NO, NO_2 and nitrogen N_2, the nitrous oxide N_2O and ammonia NH_3. Both N_2O and NH_3 were measured by the FTIR instrument. Concentrations of both species were practically equal to zero on both catalysts within the whole temperature range. The insignificant role of N_2O under lean conditions has been reported in literature *[11]*. Performed measurements imply that neither nitrous oxide nor ammonia play an important role in the chemistry of nitrogen oxides in diesel exhaust. Reactions with the formation of any of these species have been excluded from the further discussion. As there is no evidence of hydrogen in exhaust gas under lean conditions, H_2 reactions are not discussed either.

NITROGEN OXIDES REACTIONS - The following are several chemical reactions involving nitrogen oxides which occur or may be occurring in diesel exhaust. Reactions (2) and (3) represent the synthesis of NO_x as happens in the engine cylinder. Reaction (3) is in fact the global reaction standing for processes Eq.(2) + Eq.(1).

$$\tfrac{1}{2}N_2 + \tfrac{1}{2}O_2 \leftrightarrow NO \qquad (2)$$

$$\tfrac{1}{2}N_2 + O_2 \leftrightarrow NO_2 \qquad (3)$$

An alternative way to generate NO_2 from NO is the disproportionation of nitric oxide, reaction Eq.(4):

$$2NO \leftrightarrow NO_2 + \tfrac{1}{2}N_2 \qquad (4)$$

Nitrogen dioxide may react with exhaust gas components of a reducing character. Equations (5), (6) and (7) are examples of such reactions, where NO_2 reduces to NO. Reactions Eq.(5) and (6) represent oxidation of hydrocarbons and carbon monoxide by NO_2. Eq.(7) depicts the reaction between NO_2 and carbon of diesel particulates.

$$NO_2 + \{HC\} \leftrightarrow NO + CO + H_2O \qquad (5)$$

$$NO_2 + CO \leftrightarrow NO + CO_2 \qquad (6)$$

$$NO_2 + C \leftrightarrow NO + CO \qquad (7)$$

Similar set of reactions may be written for nitric oxide:

$$NO + \{HC\} \leftrightarrow N_2 + CO + H_2O \qquad (8)$$

$$NO + CO \leftrightarrow \tfrac{1}{2}N_2 + CO_2 \qquad (9)$$

$$NO + C \leftrightarrow \tfrac{1}{2}N_2 + CO \qquad (10)$$

Reaction Eq.(8) is considered to be the major mechanism of NO_x reduction on a Pt/Al_2O_3 lean NO_x catalyst *[12]*.

Finally, NO_2 can be reduced directly to N_2, Eq. (11), (12) and (13):

$$NO_2 + \{HC\} \leftrightarrow N_2 + CO + H_2O \qquad (11)$$

$$NO_2 + 2CO \leftrightarrow \tfrac{1}{2}N_2 + 2CO_2 \qquad (12)$$

$$NO_2 + 2C \leftrightarrow \tfrac{1}{2}N_2 + 2CO \qquad (13)$$

The last set of equations is formally a simple sum of previous reactions. For example, reaction Eq.(12) is the sum of reactions Eq.(6) and (9). Despite this formality, the mechanism of reaction Eq.(12) is not necessarily comprised of the processes Eq. (6) and (9). It may not include NO as the intermediate reaction product. Also the reaction kinetics may be different from the kinetics of the formal constituent processes.

REACTIONS THERMODYNAMICS - It is possible to predict the direction of a reaction in a given reacting mixture as well as the equilibrium concentrations of reactants by thermodynamic calculations. From thermochemical properties of pure reactants the *standard Gibbs free energy of reaction* ΔG_r^0 can be calculated. The equilibrium constant of a reaction K_p is related to ΔG_r^0 as follows

$$K_p\langle T\rangle = \exp\left\{\frac{\Delta G_r^0\langle T\rangle}{RT}\right\} \qquad (14)$$

where R is the universal gas constant and T is the absolute temperature in K. Both K_p and ΔG_r^0 are functions of temperature. The equilibrium constant for an equilibrium reaction between ideal-gas species

$$aA + bB + \ldots \leftrightarrow lL + mM + \ldots \qquad (15)$$

can be written as

$$K_p\langle T\rangle = \frac{(P_L)^l (P_M)^m \ldots}{(P_A)^a (P_B)^b \ldots} \qquad (16)$$

where P_i denotes the equilibrium partial pressure of species i in atmospheric units. Eq.(16) solved together with the stoichiometric mass balance of the reaction allows for the calculation of equilibrium partial pressures and concentrations in the reacting mixture.

Some of the nitrogen oxides reactions have been collected in Table 2. The standard Gibbs free energy of reaction and logarithms of equilibrium constant are listed for the temperature of 700 K (427 °C).

High value of equilibrium constant means that the given reaction may proceed to the right side of its equation. Equilibrium constant close to 1, $\ln(K_p)\approx 0$, indicates that equilibrium concentrations of products and reactants are comparable. The reaction, depending on the actual concentrations, may be in the proximity of its equilibrium point. Eq.(16) must be solved together with the mass balance to find out which direction can the reaction proceed. Very low equilibrium constant (negative $\ln(K_p)$) points that the reaction would proceed to the left side of its equation.

Reaction Eq.(2) - synthesis of NO - is the only reaction with a negative $ln(K_p)$ and the corresponding K_p of $8.2 \cdot 10^{-7}$. The generation of NO from oxygen and nitrogen under conditions in diesel exhaust is not possible. From the thermodynamic reasons the reaction can proceed only to the left side of the equation. NO in diesel exhaust is predisposed to decompose into oxygen and nitrogen. The rate of this reaction, however, is very low. At temperatures below 700 °C the speed of spontaneous NO decomposition equals practically zero.

Reaction Eq.(1) - oxidation of NO to NO_2 - is close to its equilibrium point at high temperatures in diesel exhaust. At 427 °C the equilibrium constant amounts to $exp(0.9) = 2.4$. The NO equilibrium curve is shown in Fig.6. The speed of NO oxidation on the Pt catalyst was high. Equilibrium constraints limited progress of the reaction at higher temperatures.

The reaction Eq.(4) - disproportionation of NO - shows the logarithm of K_p of 14.87 corresponding to a high value of $K_p = 2.9 \cdot 10^6$. There is no thermodynamic constraint on the progress of this process.

The other reactions in Table 2 present oxidation, by either NO or NO_2, of hydrocarbons, carbon monoxide and carbon of diesel particulates. Dodecane (n-$C_{12}H_{26}$) served as a representative of hydrocarbons, Eqns.(5a) and (8a). All of the reactions exhibit very high equilibrium constants. Logarithm of K_p varies between 29 and 52.2 yielding equilibrium constants from $3.8 \cdot 10^{12}$ to $4.5 \cdot 10^{22}$. There are no thermodynamic constraints for the oxidation of HC, CO or diesel particulate matter (DPM) by NO_x in diesel exhaust.

Table 2

Nitrogen Oxides Reactions Equilibrium Constant @700K

Reaction		$\Delta G_r^{0,700}$ kcal/gmole	$\ln(K_p^{700})$
$\frac{1}{2}N_2 + \frac{1}{2}O_2 \leftrightarrow NO$	(2)	19.49	-14.0
$NO + \frac{1}{2}O_2 \leftrightarrow NO_2$	(1)	-1.19	0.9
$2NO \leftrightarrow NO_2 + \frac{1}{2}N_2$	(4)	-20.69	14.87
$NO + \frac{1}{25}C_{12}H_{26} \leftrightarrow$ $\leftrightarrow \frac{1}{2}N_2 + \frac{12}{25}CO + \frac{13}{25}H_2O$	(8a)	-70.47	50.7
$NO + CO \leftrightarrow \frac{1}{2}N_2 + CO_2$	(9)	-72.54	52.2
$NO + C \leftrightarrow \frac{1}{2}N_2 + CO$	(10)	-60.96	43.8
$NO_2 + \frac{1}{25}C_{12}H_{26} \leftrightarrow$ $\leftrightarrow NO + \frac{12}{25}CO + \frac{13}{25}H_2O$	(5a)	-49.78	35.8
$NO_2 + CO \leftrightarrow NO + CO_2$	(6)	-51.85	37.3
$NO_2 + C \leftrightarrow NO + CO$	(7)	-40.28	29.0

Nitrogen oxides can undergo several different reactions, as shown in Table 2. Particular reactions compete for NO or NO_2, quantities of which are limited. The consumption of NO_x in different reactions depends on their speed. Equilibrium calculations yield no indication on the reaction speed. The numbers in Table 2 do not indicate which reactions are more likely to occur. It is perfectly possible that a reaction with lower equilibrium constant would proceed faster than a competitive reaction with high equilibrium constant. Speed of reactions can be selectively modified by a catalyst.

DISCUSSION OF NO_X RESULTS

Two patterns in the NO_x performance were occurring. The first one is that of *NO_x reduction* demonstrated by the Pt catalyst at temperatures above 250 °C. The other one is the *generation* of small amounts of NO_x occurring on the Pd catalyst as well as on the Pt catalyst at low temperatures.

REDUCTION OF NO_X - The reduction of NO_x was the net effect of a decrease of NO concentration accompanied by an increase of NO_2. The overall performance exhibited by the platinum catalyst and expressed in terms of total NO_x was very similar to a lean NO_x catalyst performance.

One of conceivable mechanisms is that of the selective NO reduction by hydrocarbons in lean NO_x catalysts. It is known that Pt/Al_2O_3 catalysts show the NO_x reduction activity under lean conditions. The conversion curve shows a maximum performance between 300°C and 400°C which is typical for that kind of device. The selective NO reduction mechanism is ussually explained by the reaction with hydrocarbons, Eq.(8), and, possibly, reactions (9) and (10) as well. These processes could have been happening in the Pt catalyst to a certain degree. However, they can not account for the observed NO_2 concentration profiles.

The changes in NO_2 concentration over the temperature range followed in a very systematic manner those of NO. The regularity is well pronounced in the ramp test with platinum catalyst. Changes in concentrations of both NO and NO_2 were plotted in Fig.7 - top left graph. There is a significant coincidence in temperature (250 °C) where neither NO_2 nor NO change their concentrations in the catalyst. This is the point, indicated by arrows in Fig.6, where the inlet and outlet concentration profiles of both NO and NO_2 cross. The increase of NO_2 concentration mirrors the decrease of NO with a scaling factor. The scaling factor amounts to 7 and is constant over the whole temperature range where the net reduction of NO_x takes place. Most likely, NO and NO_2 are parts of one reaction chain and their changes are related by some reaction stoichiometry.

The mirroring of NO and NO_2 concentration profiles implies that NO_2 is an important step in the NO_x removal mechanism. The suggested mechanism of NO_x removal begins with the catalytic oxidation of NO to NO_2 by means of oxygen present in the exhaust gas (Eq.(1)). Generated NO_2 reduces thereafter with the formation of nitrogen. Processes yielding the formation of N_2 from NO_2 could be either reactions with other components of diesel exhaust, Eq.(11)-(13), or direct decomposition of NO_2 into nitrogen and oxygen. In reality a combination of all the processes was probably taking place. Reaction with hydrocarbons seems to be confirmed by the maximum of the HC conversion curve in the Pt catalyst, Fig.5. The maximum hydrocarbons conversion correlates with the maximum NO_x conversion from Fig.7. A quantitative analysis, however, shows that the observed NO_x reduction was higher than the corresponding total change of reducing material, including hydrocarbons, CO as well as DPM. The DPM estimate was based on typical particulate emission from the test engine during ramp tests. To explain the NO_x reduction one must assume that some decomposition of NO_2 was happening as well.

The above consecutive $NO \rightarrow NO_2$ model accounts for the correlation in the NO and NO_2 concentration profiles and for the imbalanced but correlated changes of NO and NO_2. It also explains the declining NO_x reduction at higher temperatures by the thermodynamic constraints of the NO oxidation.

A possible parallel process is the disproportionation of NO, Eq.(4). Nitric oxide disappears from the system and nitrogen dioxide is generated. The reaction stoichiometry yields the total NO_x reduction of 50%. It is not possible to conclude if this process was occurring in the Pt catalyst. However, no matter what was its extent, it could account for an NO reduction not exceeding the NO_2 increase multiplied by the stoichiometric factor of 2 (Eq.(4)). As the experimental data show that the NO decrease is 7 times as high as the corresponding NO_2 increase, reaction Eq.(4) can not explain by itself the observed NO_x reduction.

NO_2 may play an important role in the lean NO_x catalyst chemistry. It is commonly known that NO_2 has more oxidizing character than NO. As such, it is more likely to react with exhaust gas hydrocarbons than NO. The quantities of NO_2 are significant, especially in platinum containing catalysts where a large fraction of NO is converted to NO_2. Unfortunately, most of the research done on the lean NO_x catalyst is not concerned with NO_2. Experimental work is usually limited to measurements of the total NO_x and the process mechanisms are explained by reactions of NO.

There are recent literature reports suggesting that NO_2 may be a reaction intermediate in the Cu/ZSM5 lean NO_x catalyst *[12]*. Presence of oxygen was found to be critical for the NO_x reduction. The reaction mechanism was explained by the formation of NO_2 intermediate on the copper sites. So far, there have been no reports on the role of NO_2 in a Pt/Al_2O_3 catalyst. However, the importance of oxygen for the platinum lean NO_x catalyst performance has been reported. Engler et al. *[13]* investigated the influence of the oxygen content on the lean NO_x Pt catalyst performance. They found that in the absence of oxygen no NO_x conversion was taking place. That conclusion could not be explained by the assumed NO reaction model. As the presence of oxygen is a necessary condition in the NO_2 model, Engler's results are in fact another indication that nitrogen dioxide might be a reaction intermediate on the platinum catalyst as well.

GENERATION OF NO - The generation of NO by the palladium catalyst and the platinum catalyst at low temperature is not possible within the discussed set of reactions. Nitrogen dioxide may react with reducing agents to form NO, Eq.(5)-(7). The amount of NO generated, however, cannot be higher than that of NO_2 which disappears from the system. The opposite was recorded in this study. Up to 25 ppm of NO was generated with the accompanying decrease of NO_2 of about 3 ppm.

No constant ratio between the reaction changes of NO and NO_2 was found. Also, the temperature ranges for the two reactions were different, implying that two separate processes were taking place. The decrease of NO_2 was most likely due to its reactions with reducing exhaust gas components, Eq.(5)-(7) and (11)-(13). There was no indication that NO is oxidized in the Pd catalyst. The engine out NO_2 was significantly reduced in the whole temperature range.

Some NO generation could be attributed to the catalytic oxidation of nitrogenated hydrocarbons. Their sources would be several nitrogen containing lube oil additives *[14]*, products of the nitration of lube oil hydrocarbons by the blowby exhaust gas in the crankcase *[15]* and nitrogen containing compounds of diesel fuel *[16]*. Simple calculations show, however, that this hypothesis would explain NO generation of a few ppm only and cannot account for the NO levels of 25 ppm found in this study. Admittedly, authors do not have a good theory for the mechanism of NO generation in the Pd catalyst.

CONCLUSIONS

(1) The platinum catalyst increased nitrogen dioxide concentration by up to 25 ppm. The increase of NO_2, however, was accompanied by a many times higher decrease of NO. The catalyst exhibited the lean NO_x performance with a maximum nitrogen oxides conversion efficiency of 22%.

(2) The results indicate that NO_2 played an important role in the lean NO_x catalyst reaction mechanism. In the first step NO was catalytically oxidized to NO_2. Generated NO_2 reacted subsequently to N_2 with either hydrocarbons, diesel particulates or CO as well as decomposed. Some disproportionation of NO into N_2 and NO_2 was also possible.

(3) Both NO_2 generation and total NO_x reduction on Pt catalyst show maximum between 350 and 400°C. The declining performance at higher temperatures is attributed to thermodynamic constraints of the oxidation of NO.

(4) Engine out NO_2 was reduced on the palladium catalyst throughout the tested temperature range. This was accompanied by more than equivalent increase of NO. The total NO effect was insignificant from the practical point of view with the maximum NO_x generation of 3%.

(5) Platinum catalyst was very active in respect to CO and hydrocarbons. The activity of the palladium catalyst at high temperatures (400°C) matched that of the Pt DOC, but the light-off temperatures were higher by more than 100°C.

(6) Underground mines experiencing problems with NO_2 levels should use diesel oxidation catalysts tested specifically for the NO/NO_2 shift. Some DOCs might deteriorate the ambient air quality situation while others can effectively reduce the engine out NO_2.

RECOMMENDATION - Most of the experimental work in the lean NO_x catalyst research is limited to total NO_x measurements. It is believed that separate measurements and analysis of NO *and* NO_2 are more appropriate and would cast more light on the catalytic NO_x reduction mechanism in lean exhaust.

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ATTACHMENT 3

Site Logs, Corrective Action Reports, and Semi-Annual Audits for On-Site Monitoring

From:	Melissa Polm [mpolm@swca.com]
Sent:	Thursday, July 26, 2012 12:41 PM
To:	Jamie Wilson
Cc:	Brad Sohm; Kathy Arnold
Subject:	FW: Air modeling- Rosemont
Follow Up Flag:	Follow up
Flag Status:	Completed

Jamie-
Could you please send us the actual site logs? Refer to emails before if you need clarification.
Thanks!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

From: Anderson, Bret A -FS [mailto:baanderson02@fs.fed.us]
Sent: Thursday, July 26, 2012 12:19 PM
To: Melissa Polm; Davis, Sarah L -FS; Roth, Melinda D -FS; Ehlers, Susanna M -FS
Cc: Brad Sohm
Subject: RE: Air modeling- Rosemont

Melissa,

Thanks for the email. I have already reviewed the audit logs, but I wanted the actual site logs. A standard protocol of maintaining a monitoring site is to have a site log which documents when a person arrives, what actions are performed while there, and then when they leave. Typically it is a handwritten in a notebook or other such item. If their monitoring protocol says that they will be there every two weeks for QA purposes, the site logs would document if someone actually showed and what actions were performed. My concern remains with why it took 6 weeks to detect a data logger malfunction, as that should have been picked up on a routine biweekly site visit, so the site logs would show who was there, when, and what was done.

Thanks,
Bret

From: Melissa Polm [mailto:mpolm@swca.com]
Sent: Thursday, July 26, 2012 12:52 PM
To: Davis, Sarah L -FS; Roth, Melinda D -FS; Anderson, Bret A -FS; Ehlers, Susanna M -FS
Cc: Brad Sohm; Melissa Polm
Subject: Air modeling- Rosemont

All-

We looked into the latest request from Brett and Susanna "After discussing this issue with Jack and Bret this morning, we'd like to request the site logs from Rosemont again. It is difficult to assess whether Rosemont followed their meteorological monitoring protocol without these site logs." This is what was found:

First, the information sent by Jamie Wilson (JBR) by email on July 9 included a summary report that covered the data collection through first quarter 2009. Appendices H-I of that report contain the various audit logs. However, the version of the report sent by Jamie did not contain the actual appendices, presumably for size. Those can be obtained

in their original form from Rosemont's web site (they're in Volume 4):
http://www.rosemontcopper.com/technical.html

Second, Jamie actually did send those same audit logs in a zip file in the same email on July 9. A quick spot check and they look like the same audit logs to me.

In summary, it is my belief that these are the field audit logs that Brett is looking for and has been asking for. Maybe he's thinking they would be handwritten or something, but to me it appears these are the data sheets from the audits and maintenance performed in the field. If he is looking for something different, then I think we don't fully understand what it is, and we need a more defined data request so we can track down the right material if it exists.

In any case, if the question is how often they performed maintenance/audits, we appear to have that answer from these logs, and it appears to be quarterly:

9/28/06
11/30/06
2/13/07
4/23/07
9/12/07
10/19/07
3/21/08
6/4/08
9/19/08
11/4/08
3/5/09

Whether that's appropriate or not, or whether they followed their sampling QA/QC process property, I have no idea.

Has the feedback from Brett & Susanna come in yet?

Thanks!

Melissa Polm
Planner/ Asst. Project Manager
Rosemont Copper Project

SWCA Environmental Consultants
343 W Franklin
Tucson, Arizona 85701
P 520.325.9194 x300 | C 520.250.6204

SWCA
ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.

Visit Our Website: http://www.swca.com

APPLIED ENVIRONMENTAL CONSULTANTS, INC.

(480) 829-0457 ◆ 1553 W. Elna Rae Street ◆ Tempe, Arizona 85281 ◆ Fax: (480) 829-8985

February 15, 2007

To Whom It May Concern:

I would like you to check, repair and recertify this data logger. We got into the problem with the data collected from it starting on day 356 at 1530. As you can see from the attached CD (see file RosemontSM2-12-07-B), the wind speed and wind direction data were zeros (the last three parameters). After day 361, the data in comma delimited format were mixed up until day 1 of this year. Then after the proper format came back, the data logger again did not record the wind data. Note that the wind sensor have been working fine.

When I arrived the instrument on day 44 (Feb 13), the data logger and storage module did not contain any data. I would say the last day of data recorded was on day 6. Furthermore, duplicate data period from 346 to 350 occurred on two storage modules which connected to the data logger at two different time frames (see file RosemontSM2-12-07-B and RosemontSM2-12-07-C). In addition, when I arrived the meteorological station, the time on this device was in 2000. So, I reset to the current time and date and let it collected the data for 3 hours. It worked just fine including the wind data. We are thinking that the data logger was malfunction. Would you please let us know what could be wrong?

Please call if you have any questions.

Best Regards,

Chitipong C.

Thitipong “Jeep” Chindavijak
Permit Engineer

Jamie Wilson

From:	Louis Thanukos
Sent:	Tuesday, October 02, 2012 9:29 AM
To:	Jamie Wilson
Subject:	FW: Rosemont Meteorological Monitoring Site Log Book
Attachments:	Rosemont Met Monitor Site Log Book.pdf

Jamie,

Here is the Site Log and below is the transmittal.

Louis C. Thanukos Ph.D.
Division Manager
JBR Environmental Consultants, Inc.
1553 W. Elna Rae
Tempe, AZ 85281-6935
(480) 829-0457 voice
(480) 829-8985 fax
lcthanukos@jbrenv.com
www.jbrenv.com

From: Louis Thanukos
Sent: Tuesday, August 07, 2012 1:26 PM
To: 'mpolm@swca.com'
Cc: 'Katherine Arnold'
Subject: FW: Rosemont Meteorological Monitoring Site Log Book

Hi Melissa,

Per your request, attached please find a scanned copy of the Rosemont Meteorological Monitoring Site Log Book.

Please call if you have any questions.

Louis C. Thanukos Ph.D.
Division Manager
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(480) 829-8985 fax
lcthanukos@jbrenv.com
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From: Shantanu Kongara
Sent: Friday, August 03, 2012 5:13 PM
To: Louis Thanukos
Subject: Rosemont Meteorological Monitoring Site Log Book

Louis,

Attached is the scanned version of the Rosemont Meteorological Monitoring Site Log Book.

It is also available on the Server at **Work in Progress > Ambient > Rosemont .**

Thanks

Shantanu Kongara
Permit Engineer
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[p] 480.829.0457 ext. 219
[f] 480.829.8985
skongara@jbrenv.com
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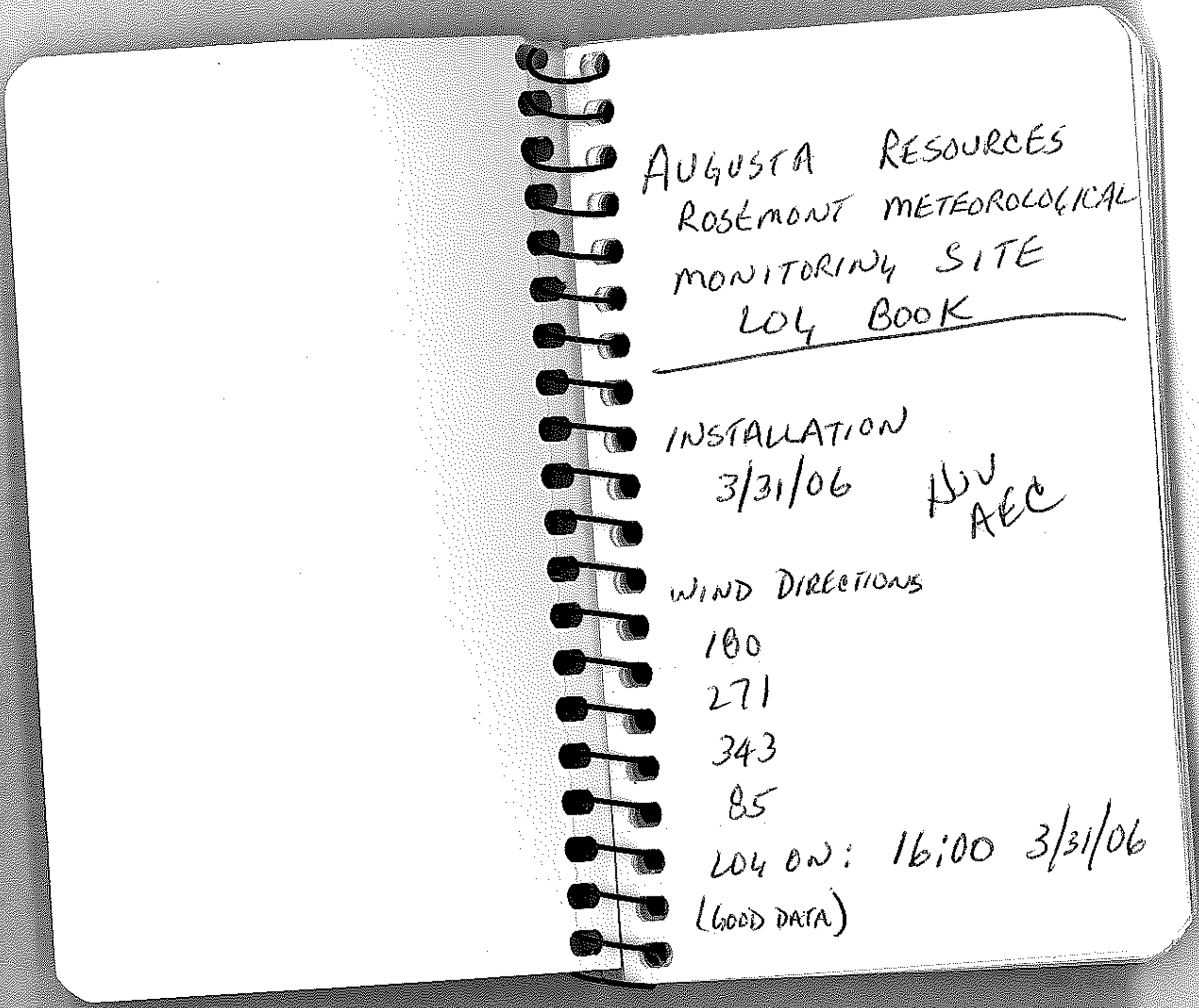
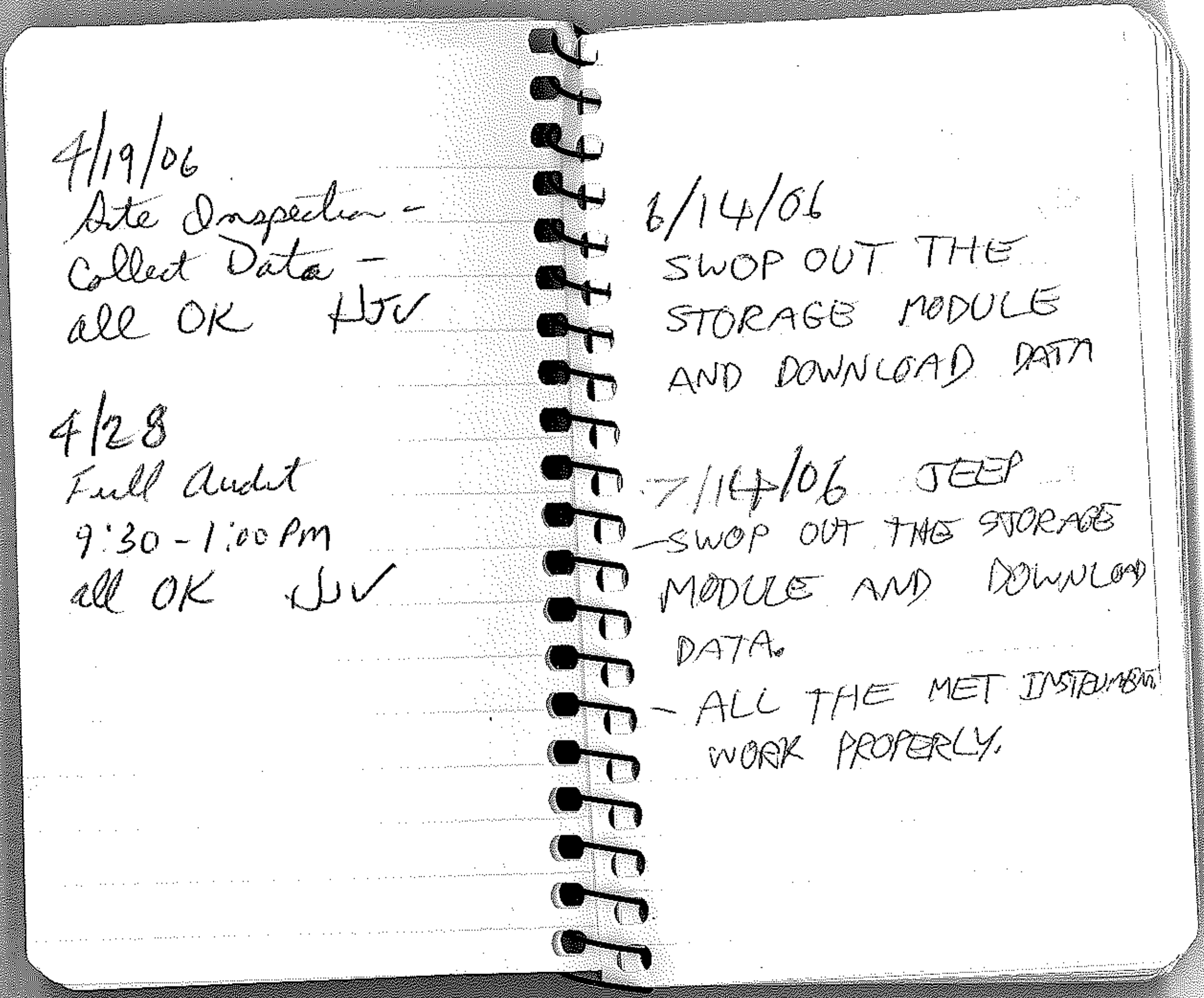


AUGUSTA RESOURCES
ROSEMONT METEOROLOGICAL
MONITORING SITE
LOG BOOK

INSTALLATION
3/31/06 HJV
AEC

WIND DIRECTIONS
180
271
343
85
LOG ON: 16:00 3/31/06
(GOOD DATA)

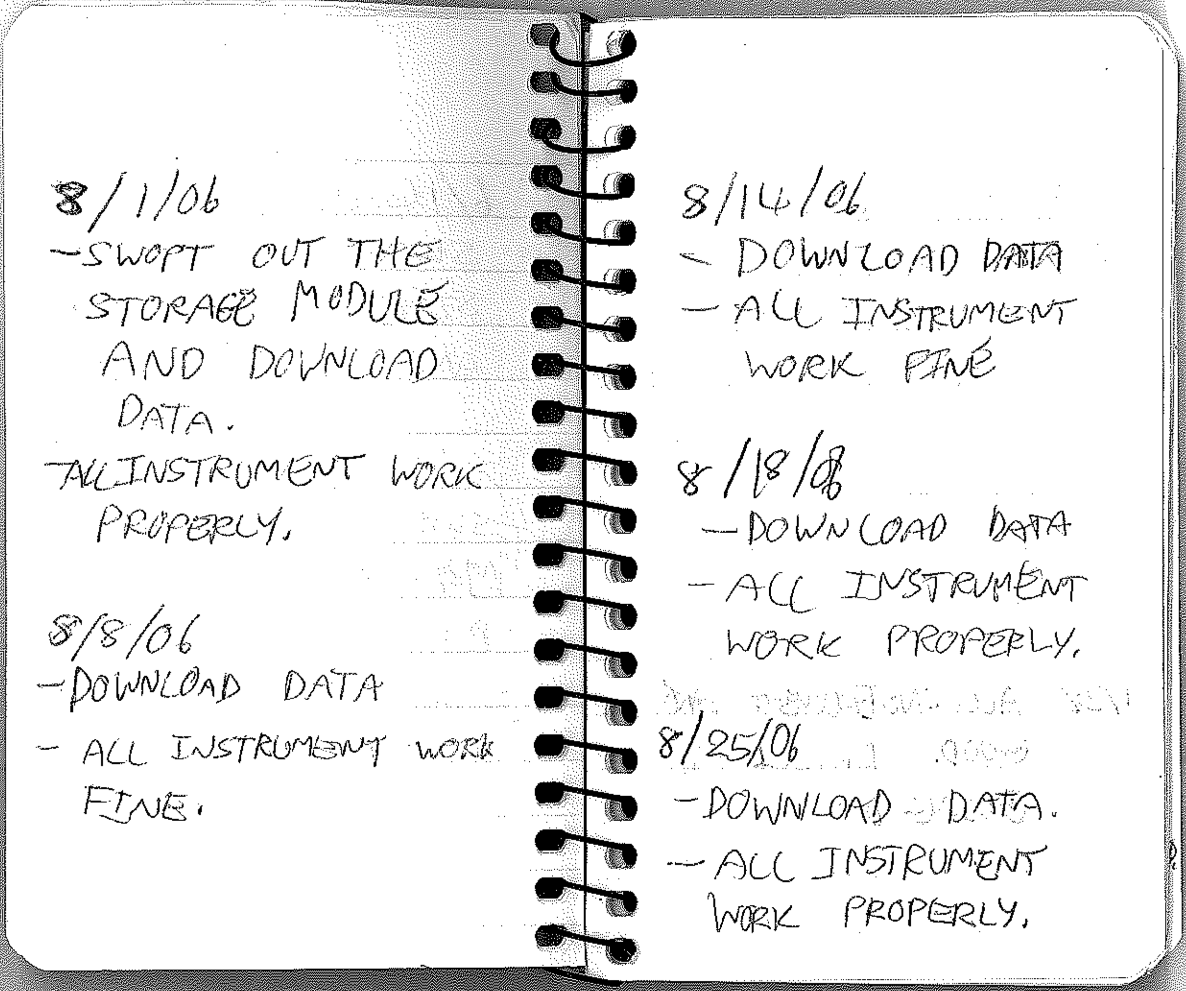


4/19/06
Site Inspection -
Collect Data -
all OK HJ✓

4/28
Full Audit
9:30 - 1:00 PM
all OK JJ✓

6/14/06
SWOP OUT THE
STORAGE MODULE
AND DOWNLOAD DATA

7/14/06 JEEP
- SWOP OUT THE STORAGE
MODULE AND DOWNLOAD
DATA.
- ALL THE MET INSTRUMENT
WORK PROPERLY.



8/1/06
-SWOPT OUT THE STORAGE MODULE AND DOWNLOAD DATA.
-ALL INSTRUMENT WORK PROPERLY.

8/8/06
-DOWNLOAD DATA
- ALL INSTRUMENT WORK FINE.

8/14/06
- DOWNLOAD DATA
- ALL INSTRUMENT WORK FINE

8/18/06
-DOWNLOAD DATA
- ALL INSTRUMENT WORK PROPERLY.

8/25/06
-DOWNLOAD DATA.
- ALL INSTRUMENT WORK PROPERLY.

8/31/06 ALL THE
12:00 INSTRUMENT WORKS
PROPERLY, THE SKY
IS PRETTY CLOUDY.
9/14 - LOOKS GOOD
9/20 DRILLING STARTED
ON 9/19 — DUSTY
SWITCHED DATA CHIP,
CLOUDY SKY
9/28 ALL INSTRUMENT ARE
GOOD. DRILLING IS
GOING ON.

10/18
STORAGE MODULE
SWAP - ALL INSTRUMENTS
OK - CLEAR/COOL
HJV

11/3 STORAGE MODULE
SWAP -
EVERYTHING LOOKS GOOD -
CLEAR ~ WARM
S-W

11/7 MODULE
CHANGES AGAIN, PER
JEEP. ALL LOOKS
OK. S-W

11/15 DOWNLOADED
DATA AND CHANGED
OUT THE STORAGE
MODULE (PUT "C"
IN)

11/30 ALL INSTRUMENT
WORKS FINE.
DO THE AUDIT TODAY.
CHANGED OUT THE SM.

12/15 WORKING FINE
S-W

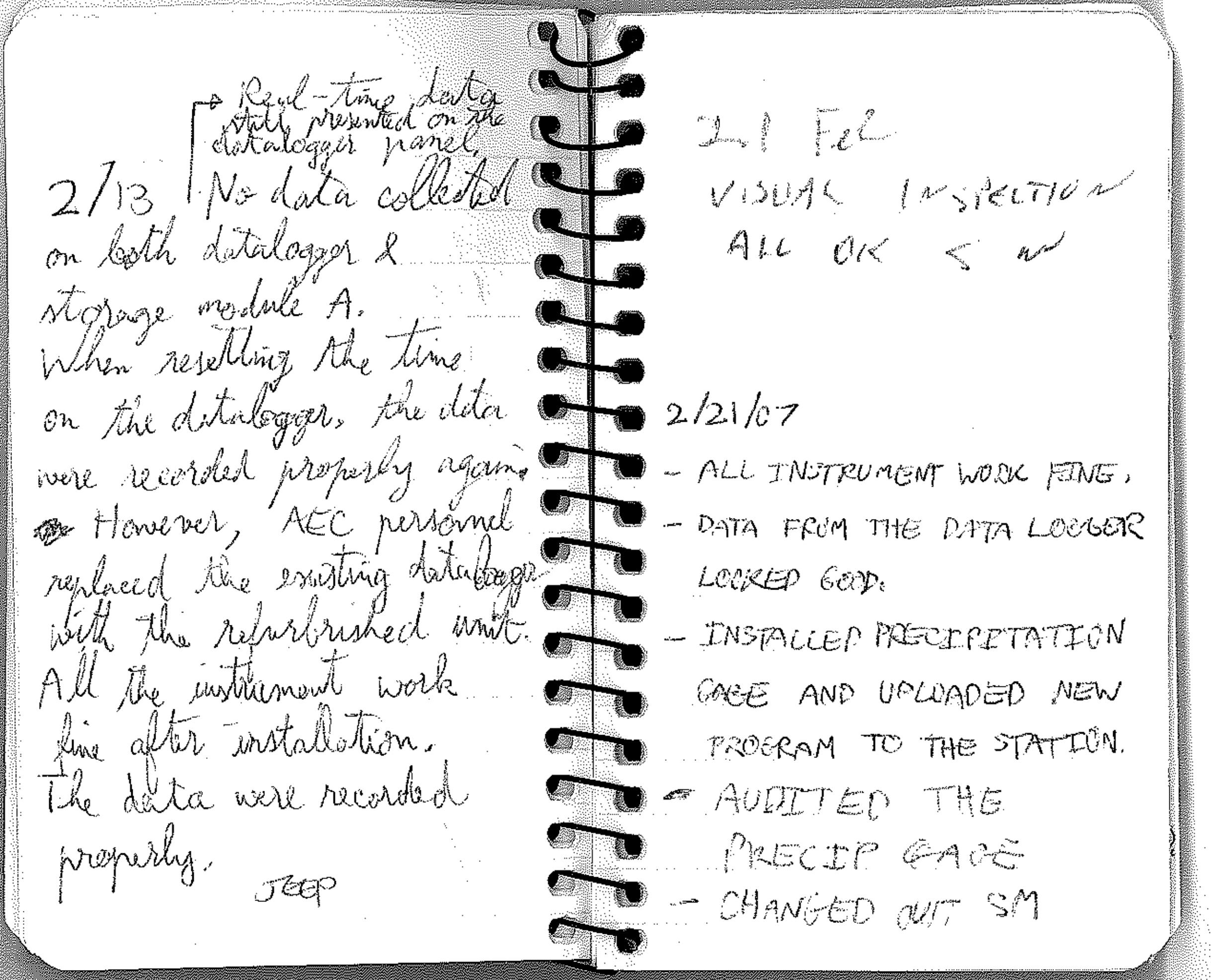
12/27 ALL OK
~~CHANGED THE LOCK~~ S-W

NEW
LOCK WOULDN'T FIT.
S-W

1/3/07
CHANGED DATA
MODULE - ALL
LOOKS GOOD

1/12/07
LOOKS GOOD
LOCK CHANGED
COLD + WINDY
S-W

1/21
6" SNOW
S-W



→ Real-time data
still presented on the
datalogger panel.

2/13 No data collected
on both datalogger &
storage module A.
When resetting the time
on the datalogger, the data
were recorded properly again.
However, AEC personnel
replaced the existing datalogger
with the refurbished unit.
All the instrument work
fine after installation.
The data were recorded
properly.
JEEP

21 Feb
VISUAL INSPECTION
ALL OK S W

2/21/07
- ALL INSTRUMENT WORK FINE.
- DATA FROM THE DATA LOGGER
LOOKED GOOD.
- INSTALLED PRECIPITATION
GAGE AND UPLOADED NEW
PROGRAM TO THE STATION.
- AUDITED THE
PRECIP GAGE
- CHANGED OUT SM

DATA CHIP "B" INSTALLED
26 Feb 07 EQUIPMENT
WORKING FINE
S-W

2/27/07
Checked and downloaded
data from met station
Instrument working properly.

chip replaced 5 Mar 07
ALL OK S-W

3/06/07 10:30
DATA COLLECTION
TO LAPTOP
ALL WORKING GOOD
NORMAL CONDITIONS.

3/12/06 chip replaced
all OK S-W

3/20/07 JM
9:00 AM
DATA COLLECTION OK
SWAP OR REPLACED
STORAGE MODULE A TO B
ALL IN GOOD RUNNING CONDITIONS

26 Mar
EQUIPMENT LOOKS OK,
DATA CHIP CHANGES
S-W

3/29/07 JONATHAN
9:00 am
COLLECTED DATA FROM
21X, ALL WORKING GOOD

2APR 07 ALL GOOD
DATA CHIP "A" INSTALLED
S-W

4/11/07 ALL INSTRUMENT
WORK FINE. CHANGED
SM "A" TO "B".

4/19 - UNABLE TO
GET UP HERE UNTIL
TODAY. "C" INSTALLED
S-W

4/23/07 CHIP EXCHANGE "C TO A"
W-SENSOR AUDIT
10 M - PROBE AUDIT
2 M AUDIT
REG. PROBE AUDIT
DATA COLLECTION

JONATHAN TREET

30 APR – DATA CHIP
"C" INSTALLED.
ALL O.K.
S-W

9/7/07 Jm
DATA COLLECTION
FROM DATALOGGER
ALL INSTRUMENT LOOK ~~A~~
✓ CHECKED OK
REPLACED ~~B~~
"C" FOR "B" CHIP

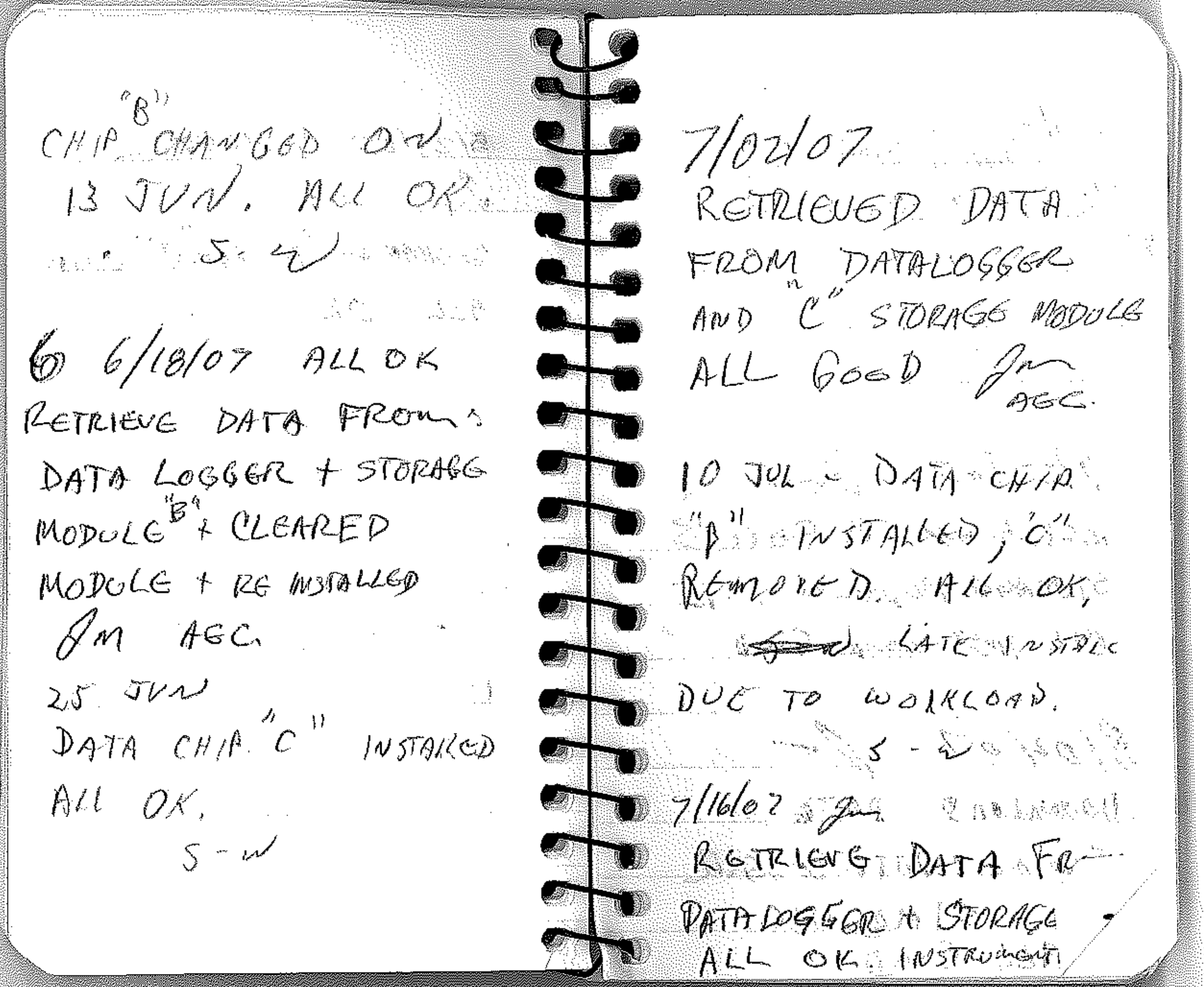
14 MAY – CHANGED
OUT A CHIP FOR B.
ALL OK gm

5/21/07 8:45 am
Jm AEC
EXCHANGE "A" FOR "C" CHIP.
ALL OK gm

29 MA 07 5:00
INSTALLED "A" CHIP
ALL OK
S-W

6/04/07 Jm AEC
DATA COLLECTION
9:30 Am CHIP + DATALOGGER
ALL INSTRUMENTS OK.

6/13
BAD STORM ON 12 JUN



CHIP "B" CHANGED ON
13 JUN. ALL OK.
S-W

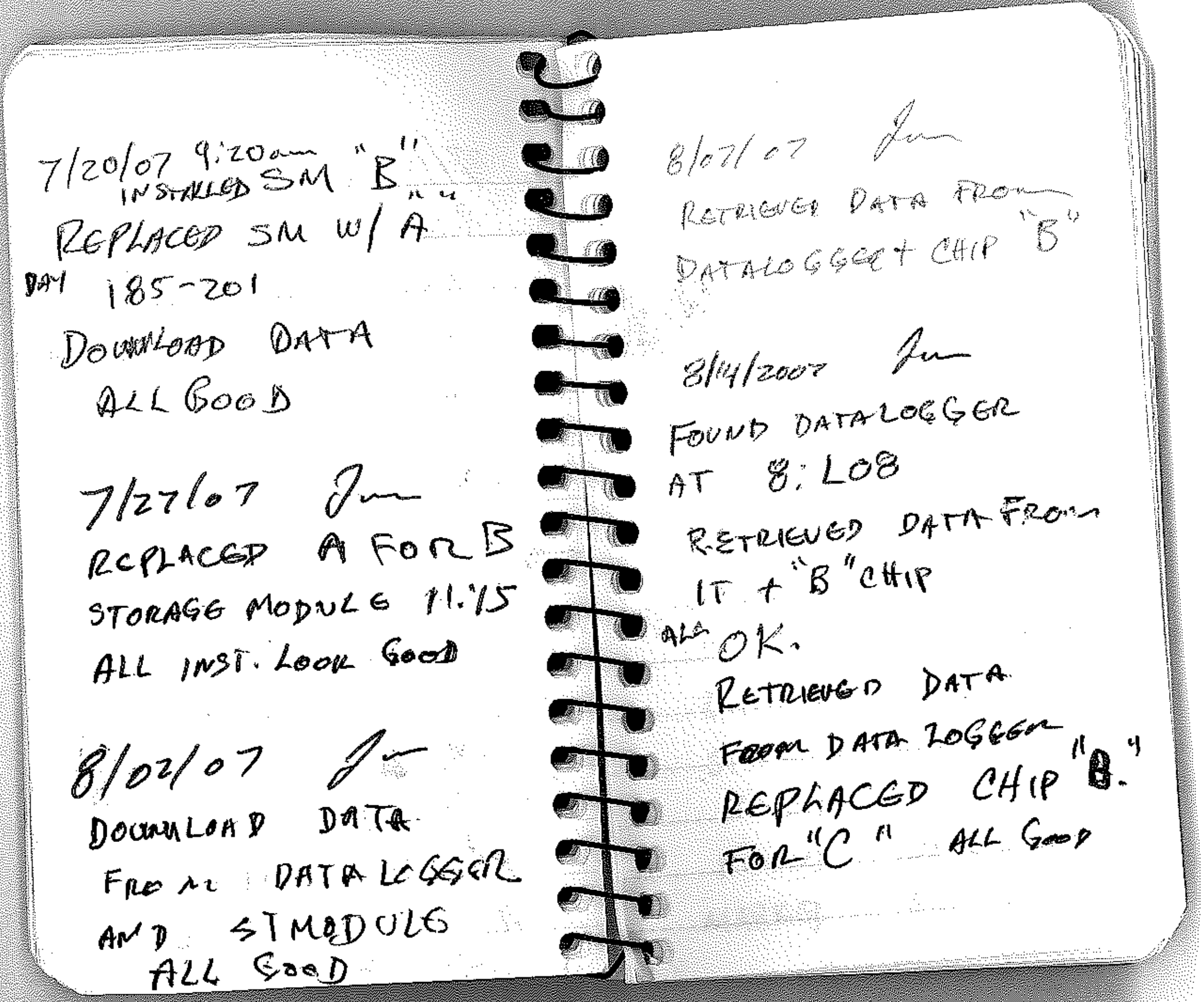
6 6/18/07 ALL OK
RETRIEVE DATA FROM
DATA LOGGER + STORAGE
MODULE "B" + CLEARED
MODULE + RE INSTALLED
JM AGC.

25 JUN
DATA CHIP "C" INSTALLED
ALL OK.
S-W

7/02/07
RETRIEVED DATA
FROM DATALOGGER
AND "C" STORAGE MODULE
ALL GOOD JM
AGC.

10 JUL - DATA CHIP
"B" INSTALLED, "C"
REMOVED. ALL OK,
LATE INSTALL
DUE TO WORKLOAD.
S-W

7/16/07 JM
RETRIEVE DATA FR
DATALOGGER + STORAGE
ALL OK. INSTRUMENT



7/20/07 9:20am "B"
INSTALLED SM "B" " "
REPLACED SM W/ A
DAY 185-201
DOWNLOAD DATA
ALL GOOD

7/27/07 Jim
REPLACED A FOR B
STORAGE MODULE 11:15
ALL INST. LOOK GOOD

8/02/07 Jim
DOWNLOAD DATA
FROM DATA LOGGER
AND STMODULE
ALL GOOD

8/07/07 Jim
RETRIEVED DATA FROM
DATALOGGER + CHIP "B"

8/14/2007 Jim
FOUND DATALOGGER
AT 8:L08
RETRIEVED DATA FROM
IT + "B" CHIP
ALL OK.
RETRIEVED DATA
FROM DATA LOGGER
REPLACED CHIP "B."
FOR "C" ALL GOOD

RETRIEVED DATA 8/27/07
CHANGED STORAGE MODULE
"C" FOR "B" ALL GOOD

8/31/07 collected data
from datalogger &
storage module, All
instrument work fine

9/7/07 RETRIEVE
DATA FROM DATA LOGGER
STORAGE MODULE DID NOT
RECORD ANY DATA
FOUND PROBL W/CABLE
MARKED IT NOT TO USE!

9/20/07 ALL OK
RETRIEVE DATA FROM
STORAGE MODULE
+ DATA LOGGER

9/26/07
DOWNLOAD DATA FROM
DATALOGGER + ST. MODULE
ALL GOOD

10/2/07
DOWNLOADED DATA
FROM THE STATION.
EVERY INSTRUMENT
WORKS FINE.

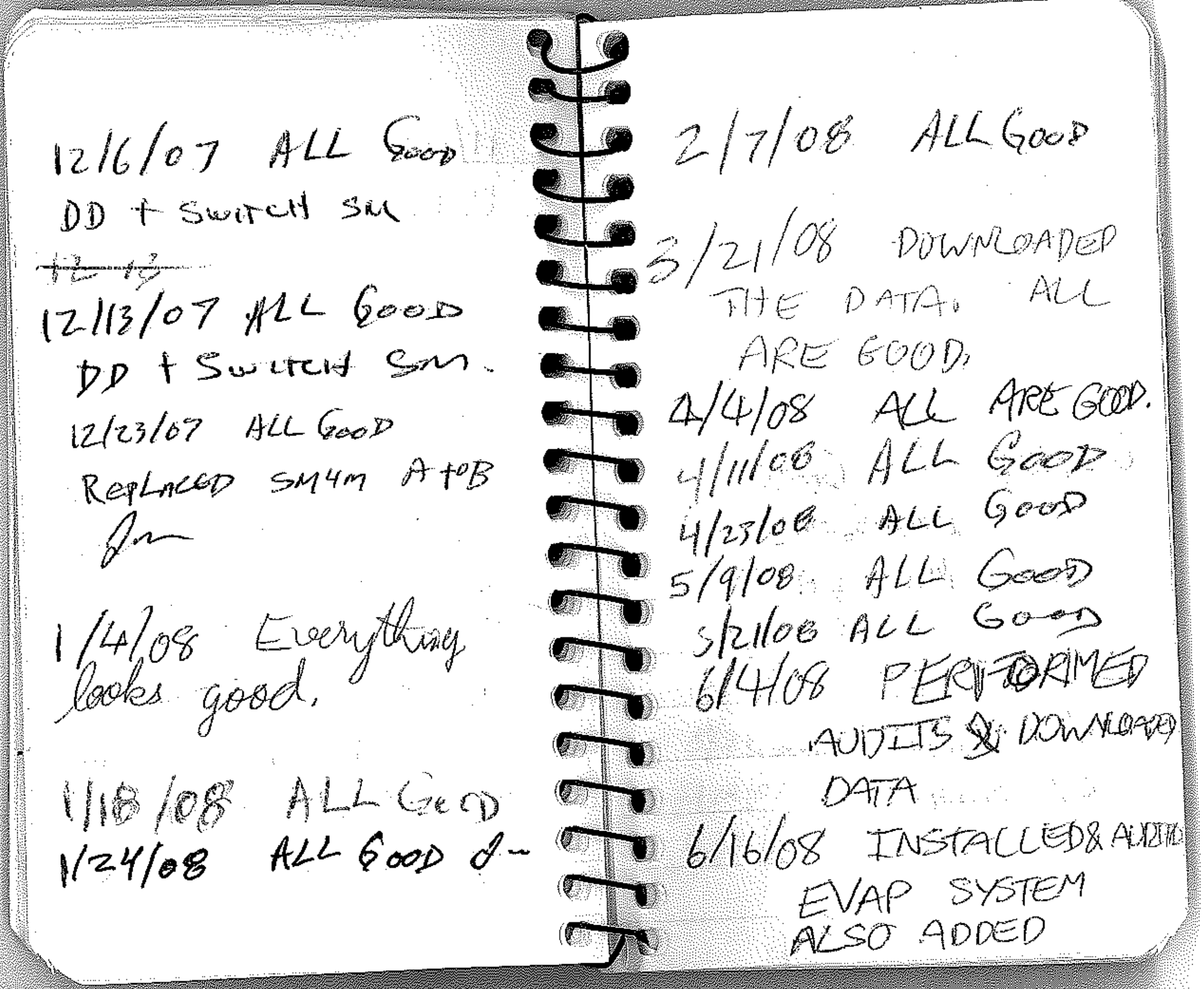
10/12/07
DOWNLOADED DATA
FROM D-LOGGER
ALL ~~Kee~~ INST. LOOK GOOD

10/19/07 TJC
AUDIT THE SYSTEM.
ALL INSTRUMENT PASSED AUDITS
DOWNLOADED DATA FROM
DATALOGGER & SM,

10/26/07
RETRIEVED DATA
DL + SM ALL GOOD

11/01/07 RETRIEVED
DATA DL + SWITCHED
SM B FOR A ALL GOOD

11/9/07 RETRIEVED
DATA DL + SM
A IN PLACE ALL GOOD
11/16/07 ALL GOOD
DATA LOGGER + SM
+ INSTRUMENTS Good
11/23/07 ALL GOOD
DD + SWITCHED SM B FOR A
11/30/07 ALL GOOD
DD + SWITCHED SM



12/6/07 ALL Good
DD + SWITCH SM
~~12 13~~
12/13/07 ALL GOOD
DD + SWITCH SM.
12/23/07 ALL GOOD
REPLACED SM4M A to B

1/4/08 Everything looks good.

1/18/08 ALL GOOD
1/24/08 ALL GOOD

2/7/08 ALL GOOD

3/21/08 DOWNLOADED THE DATA. ALL ARE GOOD.
4/4/08 ALL ARE GOOD.
4/11/08 ALL GOOD
4/23/08 ALL GOOD
5/9/08 ALL GOOD
5/21/08 ALL GOOD
6/4/08 PERFORMED AUDITS & DOWNLOADED DATA
6/16/08 INSTALLED & AUDITED EVAP SYSTEM ALSO ADDED

6/17/08
EVAP. INSTALL
ONEMORE BATTERY.
DOWNLOADED MET DATA.

6/19/08
DOWNLOADED MET DATA

6/27/08 ALL GOOD
DOWNLOAD
MET DATA

7/3/08
REPLACED SM4M
ALL GOOD

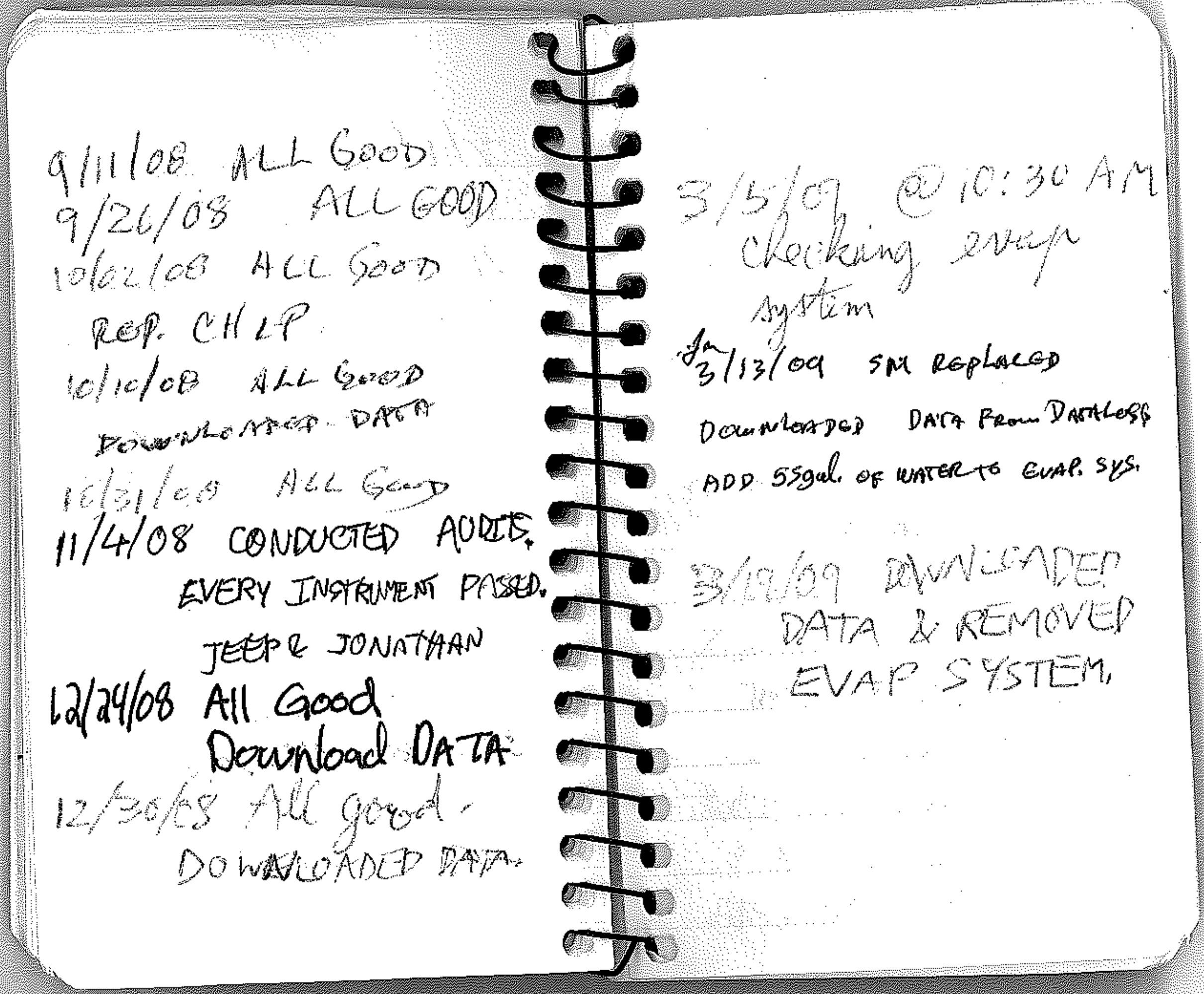
7/10/08 ALL Good
REP SM4M

7/18/08 ALLGood
DATALOGGER SM4M

7/24/08 ALL GOOD
DOWNLOAD DATALOGGER
REPLACE SM4M
ADD WATER TO HOLDING TANK

8/1/08 ALL Good
RETRIEVED DATA FROM
DATALOGGER

8/8/08 ALL Good
8/27/08 ALL GOOD
8/24/08 ALL GOOD
9/5/08 ALL Good



9/11/08 ALL GOOD
9/26/08 ALL GOOD
10/02/08 ALL GOOD
REP. CHLP
10/10/08 ALL GOOD
DOWNLOADED DATA
10/31/08 ALL GOOD
11/4/08 CONDUCTED AUDITS.
EVERY INSTRUMENT PASSED.
JEEP & JONATHAN
12/24/08 All Good
Download DATA
12/30/08 All good.
DOWNLOADED DATA.

3/5/09 @ 10:30 AM
checking evap
system
Jn 3/13/09 SM REPLACED
DOWNLOADED DATA FROM DATALOGG
ADD 55gal. OF WATER TO EVAP. SYS.

3/19/09 DOWNLOADED
DATA & REMOVED
EVAP SYSTEM.

3/30/09 RETRIEVE
Jim DATA
4/2/09 RETRIEVE
Jim DATA
4/10/09 DATA RETRIEVAL
Jim
4/24/09 Jim ALL GOOD
RETRIEVED DATA.
4/30/09 RETRIEVE DATA
ALL GOOD Jim
5/6/09 RETRIEVED DATA
Jim ALL GOOD
5/12/09 CONDUCTED AUDIT.
ALL PASSED. ALSO
DOWNLOADED MET DATA.

[illegible]/21/09
. CHANGE CHIP
ALL GOOD
5/[illegible]/09 RETRIEVE DATA
ALL GOOD Jim
REPLACED SMM 6-5-09
Jim ALL GOOD
REP. SMM 6-11-09 ALL GOOD
REP. SMM 7-2-09
7/10/09 DOWNLOADED DATA.
TESTED PRECIP. GAUGE,
IT WORKS OKAY.
8/7/09 DOWNLOADED DATA.
INSTALLED THE
EVAP PAN.

8/10/09: AUDIT ON EVAP. SENS...
[illegible] ALL GOOD

8/26/09 REFILL WATER
RES. DOWNLOAD DATA
FOUND BAT IN 2M AT
TEST EVAP. PAN SYS. Jim

9/18/09 TEST EVAP. PAN
ALL GOOD, REPLACED
SMM Jim

10/20/09 ALL GOOD.
REP. SMM

10/28/09
PRECIP. GAUGE REMOVED.

11/3/09 PRECIP GAUGE INSTALL
JIM

11/11/09 AUDITED ALL INSTRUMENT
EVERYTHING LOOKED GOOD.

12/14/09 All Good
RETRIEVED DATA Jim

2/11/10 All instrument
looks good. Retrieved
the data. Jeep & Tyler
Water filled to evap
system.

4/20/10 INSTRUMENT AUDITS,
EVERY INSTRUMENT PASSED.
FILLED UP WATER FOR
THE EVAP SYSTEM,

6/16/10 DATA RETRIEVED.
JEEP

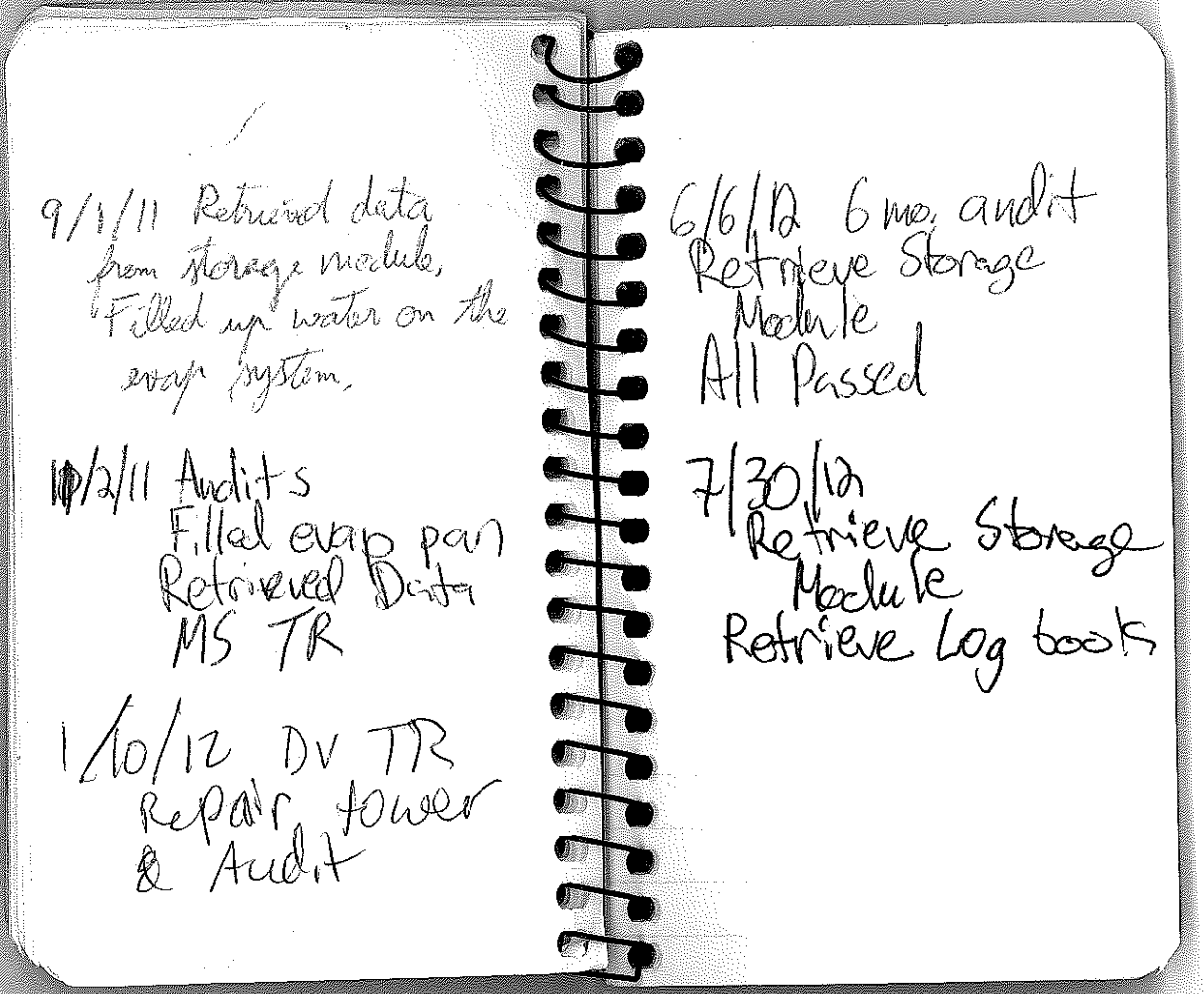
7/21/10 Obtaned storage module & Filled in water to the evaporation system.

9/16/10 Obtaned data & Filled up water in the evap system.

11/30/10 System Audit. Filled up water in the evap system. Replaced wind sensor after the audit. All are good.

3/17/11 Filled up water for evap system. Retrieved data storage module. Jeep.

5/23/11 Filled up water to the evap pan. Conducted the met instrument audit. All passed. Note that the site got vandalized. The battery enclosure was stolen. The datalogger lost its program due to battery disconnected.



9/1/11 Retrieved data
from storage module,
Filled up water on the
evap system.

10/2/11 Audits
Filled evap pan
Retrieved Data
MS TR

1/10/12 DV TR
Repair tower
& Audit

6/6/12 6 mo. audit
Retrieve Storage
Module
All Passed

7/30/12
Retrieve Storage
Module
Retrieve Log books

ATTACHMENT 4

Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAR 23 2010

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS

FROM: Stephen D. Page, Director
Office of Air Quality Planning and Standards

TO: See Addressees

This memorandum addresses the need for recommendations regarding appropriate dispersion modeling procedures which can be used to demonstrate compliance with $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). The need for these recommendations arises from several recent regulatory actions and proposals which increase the likelihood that applicants for permits under the new source review (NSR) and prevention of significant deterioration (PSD) programs may be required to demonstrate compliance with $PM_{2.5}$ NAAQS rather than relying upon the PM_{10} surrogate policy established in 1997. These recommendations are intended to facilitate appropriate and consistent implementation of current guidance regarding $PM_{2.5}$ dispersion modeling contained in the *Guideline on Air Quality Models*, Appendix W to 50 CFR Part 51, while acknowledging that such guidance is somewhat limited in detail due to technical issues associated with $PM_{2.5}$ modeling.

This memorandum provides recommendations on two aspects of the modeling procedures for demonstrating compliance with the $PM_{2.5}$ NAAQS. First, this memorandum discusses some of the technical issues that must be addressed by any applicant or permitting authority that is seeking to rely on the PM_{10} surrogate policy. Second, this memorandum provides additional information on modeling procedures to demonstrate compliance with $PM_{2.5}$ NAAQS without relying upon the PM_{10} surrogate policy.

BACKGROUND

On July 18, 1997, EPA revised the NAAQS for particulate matter to add new annual and 24-hour standards for fine particles using $PM_{2.5}$ as the indicator. EPA revised the 24-hour NAAQS for $PM_{2.5}$ on September 21, 2006, reducing the standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$. EPA also retained the previous 1997 annual standard for $PM_{2.5}$ and the 24-hour standard for PM_{10}, while revoking the previous annual standard for PM_{10}. For attainment of the new 24-hour $PM_{2.5}$ NAAQS based on ambient monitoring, the average of the 98th percentile 24-hour values over three years of monitoring must not exceed 35 $\mu g/m^3$. The annual $PM_{2.5}$ NAAQS is set at 15 $\mu g/m^3$ based on the average of the annual mean $PM_{2.5}$ concentrations over three years.

Citing significant technical difficulties with respect to $PM_{2.5}$ monitoring, emissions estimation, and modeling, EPA established a policy, known as the PM_{10} surrogate policy, on October 23, 1997. This policy allowed permit applicants to use compliance with the applicable PM_{10} requirements as a surrogate approach for meeting $PM_{2.5}$ NSR requirements until the technical difficulties were resolved. On May 16, 2008, EPA promulgated final rules governing the implementation of the NSR program for $PM_{2.5}$, which included a "grandfathering provision" allowing applicants for federal PSD permits covered by 40 CFR § 52.21, with complete permit applications submitted as of July 15, 2008, to continue relying on the PM_{10} surrogate policy. In response to a petition challenging the continued use of the PM_{10} surrogate policy for issuing PSD permits, on June 1, 2009, EPA issued a 3-month administrative stay of the grandfathering provision for $PM_{2.5}$ affecting federal PSD permits to give EPA time to propose repealing the challenged grandfathering provision. On September 16, 2009, the original 3-month stay was extended to June 22, 2010, to allow additional time for EPA to formally propose repeal of the grandfathering provision from the $PM_{2.5}$ NSR implementation rule for federal PSD permits issues under 40 CFR § 52.21. On February 11, 2010, EPA published its proposal to repeal the grandfathering provision in the *Federal Register* at 75 FR 6827. These actions cite the fact that the technical difficulties which necessitated the PM_{10} surrogate policy have been largely, although not entirely, resolved.

As part of the proposed rulemaking to repeal the grandfathering provision contained in the federal PSD program, EPA has also proposed to end the use of the PM_{10} surrogate policy for state PSD programs that EPA has approved as part of the state implementation plan (SIP) under 40 CFR § 51.166. Under the PSD programs for $PM_{2.5}$ currently in effect for SIP-approved states, states would be allowed to continue using the PM_{10} surrogate policy until May 2011, or until EPA approves the revised SIP for $PM_{2.5}$, whichever occurs first. While we continue to allow states to use the PM_{10} surrogate policy during their transition to the new $PM_{2.5}$ requirements, we have also made it clear that the policy needs to be implemented by taking into account court decisions that address the surrogacy concept. Accordingly, an applicant seeking a PSD permit under a SIP-approved PSD program may still rely upon the PM_{10} surrogate policy as long as (1) the appropriateness of the PM_{10}-based assessment for determining $PM_{2.5}$ compliance has been adequately demonstrated based on the specifics of the project; and (2) the applicant can show that a $PM_{2.5}$ analysis is not technically feasible. Absent such demonstrations, applicants would be required to submit a $PM_{2.5}$-based assessment to demonstrate compliance with the $PM_{2.5}$ standards, in addition to meeting the other requirements under the NSR/PSD programs.

PM_{10} SURROGACY DEMONSTRATIONS

Given the need for applicants that continue to rely on the PM_{10} surrogate policy to demonstrate the appropriateness of the policy based on the specifics of the project, we feel that it is appropriate and timely to address some of the technical issues associated with a surrogacy demonstration. EPA's August 12, 2009, Administrative Order in response to petitions regarding the Title V permit for Louisville Gas and Electric Company (LG&E), Trimble Generating Station, provides a brief summary of the case law history that bears on the PM_{10} surrogacy issue which suggests that an appropriateness demonstration "would need to address the differences between PM_{10} and $PM_{2.5}$."[1] The LG&E order cites two examples in this regard: 1) "emission controls used to capture coarse particles may be less effective in controlling $PM_{2.5}$"; and 2) "particles that make up $PM_{2.5}$ may be transported over long distances while coarse particles normally only travel short distances." These examples serve to highlight the two main aspects of PSD permitting for which the appropriateness of the surrogate policy should be demonstrated: 1) the Best Available Control Technology (BACT) emission control technology assessment; and 2) the ambient air quality impact assessment to demonstrate compliance with the applicable NAAQS.

While acknowledging "an evolving understanding of the technical and legal issues associated with the use of the PM_{10} Surrogate Policy," the LG&E order offers two steps as possible approaches for making an appropriateness demonstration, without suggesting that the "two steps are necessary or sufficient to demonstrate that PM_{10} is a reasonable surrogate for $PM_{2.5}$" and clearly stating that "these two steps are not intended to be the exclusive list of possible demonstrations" regarding surrogacy. The two steps offered in the LG&E order are primarily relevant to the appropriateness demonstration regarding emission controls under BACT, while the discussion here will be focused on the appropriateness demonstration in relation to ambient air impacts.

Given the range of application-specific factors that may need to be addressed for an appropriateness demonstration in relation to ambient air impacts, it is not practical to provide detailed guidance regarding how to conduct such demonstrations. However, the following list identifies some of the "differences between PM_{10} and $PM_{2.5}$" in relation to ambient air impacts that should be addressed in the development of a surrogacy demonstration:

1. While EPA revoked in 2006 the annual PM_{10} standard that was in effect when the surrogate policy, the surrogacy demonstration would still need to address the appropriateness of the PM_{10} surrogate policy in relation to the annual $PM_{2.5}$ standard, and would likely require a modeling analysis of annual PM_{10} impacts.
2. The current 24-hour NAAQS of 35 $\mu g/m^3$ is well below the previous level of 65 $\mu g/m^3$ that was in effect when the PM_{10} surrogate policy was established. The background monitored levels of $PM_{2.5}$ are, therefore, likely to account for a more significant fraction of the cumulative impacts from a modeling analysis relative to the current 24-hour $PM_{2.5}$ NAAQS than for PM_{10}.
3. Secondary formation of $PM_{2.5}$ from emissions of NO_x, SO_x and other compounds from sources across a large domain will often contribute significantly to the total ambient levels of $PM_{2.5}$, and may be the dominant source of ambient $PM_{2.5}$ in some cases. In contrast, secondarily formed particles are less likely to be significant portion of PM_{10}, which may result in significant differences in the spatial and temporal patterns of ambient impacts between $PM_{2.5}$ and PM_{10}.

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[1] A discussion of the case law that bears on the PM_{10} surrogacy issue also appears in the February 11, 2010, proposed rule at 75 FR 6831-6832.

4. The probabilistic form of the $PM_{2.5}$ NAAQS, based on the multiyear average of the 98th percentile for the daily standard, differs from the expected exceedance form of the PM_{10} NAAQS, which allows the standard to be exceeded once per year on average using the high-sixth-high (H6H) value over 5 years. These differences affect the temporal and spatial characteristics of the ambient air impacts of PM_{10} and $PM_{2.5}$. Differences in the form of the NAAQS also complicate the process of combining modeled impacts with monitored background levels to estimate cumulative impacts under the NSR/PSD permitting programs, as well as the determination of whether modeled impacts from the facility will cause a significant contribution to any modeled violations of the NAAQS that may occur.

These factors complicate the viability of demonstrating the appropriateness of the PM_{10} surrogate policy to comply with the requirement for a $PM_{2.5}$ ambient air quality impact assessment. In light of these complications, applicants may elect to use $PM_{2.5}$ dispersion modeling to explicitly meet the requirement of an ambient air quality impact assessment under the PSD permitting program, provided that the technical difficulties with respect to $PM_{2.5}$ monitoring, emissions estimation, and modeling have been sufficiently resolved in relation to the specific application.

For surrogacy demonstrations, it is assumed that as an initial step the applicant will have conducted an appropriate dispersion modeling analysis which demonstrates compliance with the PM_{10} NAAQS, including an analysis of annual PM_{10} impacts to address item 1. A simple example illustrating when a PM_{10} modeling analysis might serve as a surrogate for $PM_{2.5}$ modeling would be if a clearly conservative assumption is made that all PM_{10} emissions are $PM_{2.5}$, and the modeled PM_{10} impacts are taken as a direct surrogate for $PM_{2.5}$ impacts and compared to the $PM_{2.5}$ NAAQS. If an adequate accounting for contributions from background $PM_{2.5}$ concentrations to the cumulative impact assessment can be made, and a reasonable demonstration that the modeled PM_{10} emission inventory adequately accounted for potential nearby sources of $PM_{2.5}$, then the appropriateness of surrogacy could be reasonably found in this example. An analysis of source-specific $PM_{2.5}$/ PM_{10} emission factor ratios may also support the assumption of a more realistic, yet still conservative approach for taking a ratio of modeled PM_{10} ambient impacts to provide conservative estimates of $PM_{2.5}$ impacts.

While additional modeling analyses, short of explicit $PM_{2.5}$ modeling, may also be used to the support the surrogacy demonstration in some cases, it is important to make a clear distinction between modeling analyses for purposes of surrogacy demonstrations and modeling analyses that are intended to explicitly demonstrate compliance with the $PM_{2.5}$ standards. The distinction between these two types of modeling analyses may not always be clear, but one important distinction is whether or not a $PM_{2.5}$ emission inventory has been developed as the basis for the modeling. The distinction between these types of modeling is important because modeling procedures that may be considered appropriate for one type of analysis may not be appropriate for the other. The following section elaborates further on this point.

$PM_{2.5}$ MODELING ANALYSES

The differences between PM_{10} and $PM_{2.5}$ described above in relation to surrogacy demonstrations, especially items 2 through 4, also have implications on how best to conduct an explicit $PM_{2.5}$ NAAQS compliance demonstration through dispersion modeling. Due to the potentially significant contribution from secondary formation of $PM_{2.5}$, and the more prominent role of monitored background concentrations of $PM_{2.5}$ in the cumulative analysis, certain aspects of standard modeling practices used for PM_{10} and other criteria pollutants may not be appropriate for $PM_{2.5}$. Our recommendations for addressing these issues in terms of explicit $PM_{2.5}$ modeling analyses are described in more detail below.

Given the issues listed above, and especially the important contribution from secondary formation of $PM_{2.5}$, which is not explicitly accounted for by the dispersion model, PSD modeling of $PM_{2.5}$ should currently be viewed as screening-level analyses, analogous to the screening nature of the guidance in Section 5.2.4 of Appendix W regarding dispersion modeling for NO_2 impacts given the importance of chemistry in the conversion of NO emissions to ambient NO_2. The screening recommendations presented below for demonstrating compliance with the $PM_{2.5}$ NAAQS through dispersion modeling have been developed with the factors listed above in mind. As with any modeling analysis conducted under Appendix W, alternative models and methods may be considered on a case-by-case basis, subject to approval by the Regional Office in accordance with the recommendations in Section 3.2 on "Use of Alternative Models."

The following sections describe the recommended modeling methods for the two main stages in a typical PSD ambient air quality analysis: 1) preliminary significant impact analysis; and 2) cumulative impact assessment. The rationale for the recommendations is also provided.

Preliminary Significant Impact Analysis

The initial step in air quality impact assessments under NSR/PSD is typically a significant impact level analysis to determine whether the proposed emissions increase from the proposed new or modified source (i.e., project emissions) would have a "significant" ambient impact. Thus, the first step of the ambient impact analysis is to determine whether those emissions would result in ambient air concentrations that exceed a de minimis level, referred to as the Significant Impact Level (SIL). If modeled impacts from the facility do not exceed the SIL, then the permitting authority may be able to conclude, based on this preliminary analysis, that the project would not cause or contribute to a violation of the NAAQS. Under these circumstances, EPA would not consider it necessary for the facility to conduct a more comprehensive cumulative impact assessment that would involve modeling the facility's total emissions along with emissions from other nearby background sources, and combining impacts from the modeled emission inventory with representative ambient monitored background concentrations to estimate the cumulative impact levels for comparison to the NAAQS. The SIL is also used to establish the significant impact area of the facility for purposes of determining the geographic range of the background source emission inventory that would be appropriate should a cumulative impact assessment be necessary.

EPA's 2007 proposed rule to establish PSD increments, SILs, and a Significant Monitoring Concentration (SMC) for $PM_{2.5}$ included three options for the $PM_{2.5}$ SILs for both the 24-hour and annual NAAQS. Until the $PM_{2.5}$ SILs are finalized, the proposed SILs may not be presumed to be appropriate de minimis impact levels. However, EPA does not preclude states from adopting interim de minimis impact levels for $PM_{2.5}$ to determine whether a cumulative impact analysis will be necessary, provided that states prepare an appropriate record to support the value used. Such de minimis levels do not necessarily have to match any of the SILs that have been proposed for $PM_{2.5}$, but the levels proposed by EPA and the record supporting EPA's proposed rule could be considered in the state's determination.

The modeling methods used in this initial significant impact assessment phase of the $PM_{2.5}$ analysis, based on either a state's interim de minimis levels or EPA-finalized SILs, are similar to the methods used for other pollutants, including the use of maximum allowable emissions. However, due to the probabilistic form of the NAAQS, we recommend that the highest average of the modeled annual averages across 5 years for National Weather Service (NWS) meteorological data or the highest modeled annual average for one year of site-specific meteorological data be compared to the annual screening level (SIL). Similarly, the highest average of the maximum 24-hour averages across 5 years for NWS meteorological data or the highest modeled 24-hour average for one year of site-specific meteorological data should be compared to the 24-hour screening level (SIL).

Using the average of the highest values across the years modeled preserves one aspect of the form of the NAAQS, while using the average of the <u>first</u> highest 24-hour averages rather than the 98th percentile (8th highest) values from the distribution is consistent with the screening-level nature of the analysis. In addition, since the $PM_{2.5}$ NAAQS is based on air quality levels averaged over time, it is appropriate to use an average modeled impact for comparison to the SIL since that will more accurately characterize the modeled contribution from the facility in relation to the NAAQS than use of the highest modeled impacts from individual years. At the present time, the dispersion modeling recommendations presented here are based on modeling only the primary or direct $PM_{2.5}$ emissions from the facility.

Cumulative Impact Assessment

Unless modeled ambient air concentrations of $PM_{2.5}$ from the project emissions are shown to fall below the state's de minimis level or EPA's promulgated SIL (when finalized), then a cumulative impact assessment would be necessary to account for the combined impact of facility emissions, emissions from other nearby sources, and representative background levels of $PM_{2.5}$ within the modeling domain. The cumulative impacts are then compared to the NAAQS to determine whether the facility emissions will cause or contribute to a violation of the NAAQS. Several aspects of the cumulative impact assessment for $PM_{2.5}$ will be comparable to assessments conducted for other criteria pollutants, while other aspects will differ due to the issues identified above.

Modeling Inventory

The current guidance on modeling emission inventories contained in Section 8.1 of Appendix W will generally be applicable for the $PM_{2.5}$ modeling inventory, recognizing that these recommendations only address modeling of primary $PM_{2.5}$ emissions. The guidance in Appendix W addresses the appropriate emission level to be modeled, which in most cases is the maximum allowable emission rate under the proposed permit. Nearby sources that are expected to cause a significant concentration gradient in the vicinity of the facility should generally be included in the modeled inventory. Since modeling of $PM_{2.5}$ emissions has not been a routine requirement to date, the availability of an adequate $PM_{2.5}$ emission inventory for background sources may not exist in all cases. Recommendations for developing $PM_{2.5}$ emission inventories for use in PSD applications will be addressed separately, but existing PM_{10} inventories may provide a useful starting point for this effort.

Monitored Background

The determination of representative background monitored concentrations of $PM_{2.5}$ to include in the $PM_{2.5}$ cumulative impact assessment will entail different considerations from those for other criteria pollutants. An important aspect of the monitored background concentration for $PM_{2.5}$ is that the monitored data should account for the contribution of secondary $PM_{2.5}$ formation representative of the modeling domain. As with other criteria pollutants, consideration should also be given to the potential for some double-counting of the impacts from modeled emissions that may be reflected in the background monitoring, but this should generally be of less importance for $PM_{2.5}$ than the representativeness of the monitor for secondary contributions. Also, due to the important role of secondary $PM_{2.5}$, background monitored concentrations of $PM_{2.5}$ are likely to be more homogeneous across the modeling domain in most cases, compared to other pollutants. We plan to address separately more detailed guidance on the determination of representative background concentrations for $PM_{2.5}$.

Comparison to NAAQS

Combining the modeled and monitored concentrations of $PM_{2.5}$ for comparison to the $PM_{2.5}$ NAAQS also entails considerations that differ from those for other criteria pollutants, due to the issues identified above. Given the importance of secondary contributions for $PM_{2.5}$ and the typically high background levels relative to the NAAQS for $PM_{2.5}$, greater emphasis is placed on the monitored background contribution relative to the modeled inventory. Also, given the probabilistic form of the $PM_{2.5}$ NAAQS, careful consideration must be given to how the monitored and modeled concentrations are combined to estimate the cumulative impact levels.

The representative monitored $PM_{2.5}$ design value, rather than the overall maximum monitored background concentration, should be used as a component of the cumulative analysis. The $PM_{2.5}$ design value for the annual averaging period is based on the 3-year average of the annual average $PM_{2.5}$ concentrations; for the 24-hour averaging period, the design value is based on the 3-year average of the 98th percentile 24-hour average $PM_{2.5}$ concentrations for the daily standard. Details regarding the determination of the 98th percentile monitored 24-hour value based on the number of days sampled during the year are provided in the ambient monitoring regulations, Appendix N to 40 CFR Part 50.

The modeled annual concentrations of (primary) $PM_{2.5}$ to be added to the monitored annual design value should be computed using the same procedure used for the initial significant impact analysis based on the highest average of the modeled annual averages across 5 years for NWS meteorological data or the highest modeled annual average for one year of site-specific meteorological data. The resulting cumulative annual concentration would then be compared to the annual $PM_{2.5}$ NAAQS of 15 $\mu g/m^3$.

For the 24-hour NAAQS analysis, the modeled concentrations to be added to the monitored 24-hour design value should be computed using the same procedure used for the preliminary analysis based on the highest average of the maximum modeled 24-hour averages across 5 years for NWS meteorological data or the maximum modeled 24-hour average for one year of site-specific meteorological data. As noted above, use of the average modeled concentration across the appropriate time period more accurately characterizes the modeled contribution from the facility in relation to the NAAQS than use of the highest modeled impact from individual years, while using the average of the first highest 24-hour averages rather than the 98th percentile (8th highest) values is consistent with the screening nature of $PM_{2.5}$ dispersion modeling. Furthermore, combining the 98th percentile monitored with the 98th percentile modeled concentrations for a cumulative impact assessment could result in a value that is below the 98th percentile of the combined cumulative distribution and would, therefore, not be protective of the NAAQS.

The recommendations provided above constitute a First Tier modeling analysis for $PM_{2.5}$ compliance demonstrations. For applications where impacts from primary $PM_{2.5}$ emissions are not temporally correlated with background $PM_{2.5}$ levels, combining the modeled and monitored contributions as described above may be overly conservative. In these cases, a Second Tier modeling analysis may be considered that would involve combining the monitored and modeled $PM_{2.5}$ concentrations on a seasonal or quarterly basis, and re-sorting the total impacts across the year to determine the cumulative design value. We plan to provide separately additional details regarding this Second Tier, including a discussion of circumstances where this approach may be appropriate.

Determining Significant Contributions to Modeled Violations

If the cumulative impact assessment following these screening recommendations results in modeled violations of the $PM_{2.5}$ NAAQS, then the applicant will need to determine whether the facility emissions are causing a significant contribution to those modeled violations. A "significant contribution" determination is based on a comparison of the modeled impacts from the project emissions associated with the modeled violation to the appropriate SIL. The significant contribution determination should be made following the same procedures used during the initial significant impact analysis, based on a comparison of the average of the modeled concentrations at the receptor location showing the violation, across 5 years for NWS meteorological data and the highest modeled concentration for one year of site-specific meteorological data. For a violation of the annual NAAQS, the average of the annual values at the affected receptor(s) is compared to the SIL, while the average of the highest 24-hour average concentrations at the affected receptor(s) should be used for the 24-hour NAAQS. Use of the average modeled concentration is appropriate in this context since it is consistent with the actual contribution of the facility to the cumulative impacts at the receptor(s) showing violations and accounts for the fact that modeled violations of the 24-hour NAAQS represent average impacts across the modeling period.

Synopsis

Significant Impact Analysis: Compare the average of the highest modeled individual year's annual averages and the average of the first highest individual year's 24-hour average concentrations from project emissions to their respective screening levels, which may be based on the state's de minimis levels or EPA-finalized SILs. If modeled impacts exceed the screening levels, a cumulative impact assessment would need to be performed.

Cumulative Impact Assessment: Develop an emission inventory of background sources to be included in the modeling analysis using traditional guidance. That would include using the significant impact area established in the initial significant impact analysis, plus a 50-km annular ring to determine the geographic extent of the background emission inventory. From data obtained within this combined area, compare the average of the highest modeled individual year's annual averages and the average of the first highest individual year's 24-hour averages, plus representative background monitored concentrations, to their respective NAAQS. Monitored background concentrations are based on the 3-year average of the annual $PM_{2.5}$ concentrations, and the 3-year average of the 98th percentile 24-hour averages. To determine whether the proposed project's emissions cause a significant contribution to any modeled violations of the NAAQS, the proposed project's impacts at the affected receptor(s) are determined based on the average of the highest modeled individual years' annual averages and average of the first highest individual years' 24-hour averages from the proposed project's emissions, and are compared to the state's de minimis levels or EPA-finalized SILs.

Additional Caveats

A few additional caveats should be considered while implementing these recommendations:

1. The current preferred dispersion model for near-field $PM_{2.5}$ modeling, AERMOD, does not account for secondary formation of $PM_{2.5}$. Therefore, any secondary contribution of the facility's or other modeled source's emissions is not explicitly accounted for. While representative background monitoring data for $PM_{2.5}$ should adequately account for secondary contribution from background sources in most cases, if the facility emits significant quantities of $PM_{2.5}$ precursors, some assessment of their potential contribution to cumulative impacts as secondary $PM_{2.5}$ may be necessary. In determining whether such contributions may be important, keep in mind that peak impacts due to facility primary and secondary $PM_{2.5}$ are not likely to be well-correlated in space or time, and these relationships may vary for different precursors. We plan to issue separately additional guidance regarding this issue.

2. While dry and/or wet deposition may be important processes when estimating ambient concentrations of particulate matter (PM) in general, these factors are expected to be minor for $PM_{2.5}$ due to the small particle size. In addition, there may be additional uncertainty associated with deposition modeling for $PM_{2.5}$ due to the variable makeup of the constituent elements for $PM_{2.5}$ and the fact that deposition properties may vary depending on the constituent elements of $PM_{2.5}$. Therefore, use of deposition algorithms to account for depletion in estimating ambient $PM_{2.5}$ concentrations should be done with caution and only when clear documentation and justification of the deposition parameters is provided.
3. While EPA has proposed PSD increments for $PM_{2.5}$, the increments have not been finalized yet. Until the increments are finalized, no increment analysis is required for $PM_{2.5}$. However, it should be noted that some of the recommendations presented here in relation to NAAQS modeling analyses may need to be modified for $PM_{2.5}$ increment analyses due to the differences between the forms of the NAAQS and increments. We plan to provide further clarification of these differences separately, once the increments are finalized.

This memorandum presents EPA's views on these issues concerning modeling procedures for demonstrating compliance with the $PM_{2.5}$ NAAQS. The statements in this memorandum do not bind State and local governments and the public as a matter of law. If you have any questions concerning this memorandum, please contact Tyler Fox, Leader, Air Quality Modeling Group at (919) 541-5562.

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ATTACHMENT 5

August 31, 2009 EPA/OAQPS Model Clearinghouse Memorandum

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 31 2009

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Clarification on EPA-FLM Recommended Settings for CALMET

TO: Regional Modeling Contacts

FROM: Tyler J Fox, Group Leader
Air Quality Modeling Group, C439-01

The purpose of this memorandum is to update the draft recommendations for CALMET settings that were provided previously with the draft *Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations* (EPA, 2009).

On May 15, 2009, the EPA Model Clearinghouse issued a memorandum addressing a number of issues related to the operation of the CALMET diagnostic meteorological model in regulatory modeling applications for long-range transport (LRT). Additionally, a draft version of revisions to the existing IWAQM Phase 2 guidance was released on May 27, 2009 to provide technical context for the Clearinghouse memorandum. This draft document outlined a series of recommendations for CALMET settings that were intended to facilitate the direct "pass-through" of prognostic meteorological data to the CALPUFF modeling system using the same horizontal and vertical grid structure of the parent prognostic data set. This purpose is consistent with one of our overarching goals expressed at the 8th Conference on Air Quality Modeling promoting the use of prognostic meteorological model products in regulatory dispersion modeling applications.

Due to the time sensitive nature of the Clearinghouse memorandum, it was not possible to complete extensive testing of the recommended CALMET operational settings prior to release of the memorandum and draft IWAQM reassessment report. Subsequent testing of the CALMET model with the proposed settings against mesoscale tracer databases indicates that CALMET/CALPUFF performance using the draft recommendations deteriorates somewhat in comparison to other MM5/CALMET horizontal grid configurations that were tested. Specifically, testing against the Cross-Appalachian Tracer Experiment (CAPTEX) mesoscale tracer study dataset showed that when MM5 and CALMET were run on the same horizontal grid resolution, performance was poorer than other MM5/CALMET grid configurations tested. While the performance deterioration was not drastic, it was significant. These results have caused us to reconsider our interim guidance because it is inconsistent with our desire to promote the use of both the best meteorological products and prognostic data in general. The use of

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		IFORMC	Cloud data format	2	2
5 - Wind field options and parameters		IWFCOD	Wind model options	1	1
		IFRADJ	Compute Froude number adjustment effects	1	1
		IKINE	Compute Kinematic effects	0	0
		IOBR	Use O'Brien procedures for adjust vertical velocity	0	0
		ISLOPE	Compute slope effects	1	1
		IEXTRP	Extrapolate sfc wind obs to upper levels	-4	-4
		ICALM	Extrapolate sfc winds even if calm	0	0
		BIAS	Surface/upper weighting factors (BIAS (NZ))	NZ*0	10*0
		RMIN2	Minimum distance for extrapolation of winds	4	-1
		IPROG	Use prognostic model winds as input to diagnostic wind model	0	14
		ISTEPPG	Timestep (hours) of prognostic model data	1	1
		IGFMET	Use coarse CALMET fields as initial guess	0	0
		LVARY	Use varying radius of influence	F	F
		RMAX1	Maximum radius of influence in surface layer (km)	User defined	100
		RAMX2	Maximum radius of influence over land aloft (km)	User defined	200
		RMAX3	Maximum radius of influence over water (km)	User defined	200
		RMIN	Minimum radius of influence in wind field interpolation (km)	0.1	0.1
		TERRAD	Radius of influence of terrain features (km)	User defined	15
		R1	Relative weight at surface of 1st guess fields and obs (km)	User defined	50
		R2	Relative weight aloft of 1st guess fields and obs (km)	User defined	100
		RPROG	Weighting factors of prognostic wind field data (km)	User defined	0
		DIVLIM	Maximum acceptable divergence	5.0E-06	5.0E-06

Subject: FW: Response to letter dated August 20, 2012
Attachments: Response to letter dated 20Aug12.pdf

From: Kathy Arnold [mailto:karnold@rosemontcopper.com]
Sent: Tuesday, October 09, 2012 12:24 PM
To: Upchurch, Jim -FS
Cc: Chris Garrett
Subject: Response to letter dated August 20, 2012

Jim
Please find attached the response to questions and issues raised your letter dated August 20, 2012.

Regards,
Kathy

Kathy Arnold | **Vice President Environmental and Regulatory Affairs**
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