Scott Bohning/R9/USEPA/US
05/10/2005 06:05 PM

To: Karen Vitulano/R9/USEPA/US@EPA, Robert Baker/R9/USEPA/US@EPA, Doug McDaniel/R9/USEPA/US@EPA, Steve
cc:
bcc:
Subject: Fw: Desert Rock 5/3 meeting notes, call 5/12 reminder

EPA folk --- FYI....
----- Forwarded by Scott Bohning/R9/USEPA/US on 05/10/2005 06:04 PM -----

Scott Bohning/R9/USEPA/US
05/10/2005 06:04 PM

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Subject: Desert Rock 5/3 meeting notes, call 5/12 reminder

All -

Sorry for the delay in getting this out!

Below, in addition to my full notes (4 pages) from our 5/3/05 meeting about visibility modeling for Desert Rock Energy Facility, I have attached text-only versions of presentations made by Bob Paine, ENSR and Bret Schichtel, NPS (the original PowerPoint versions are 886 KB and 62 MB, respectively).

Excerpt from Notes from 5/3/05 meeting on Desert Rock Energy Facility visibility modeling,
held at CIRA office, Fort Collins, CO (sjb 5/10/05)

Attendees: NPS, CIRA, EPA, DPA, Ater Wynne LLP, SGP, ENSR, NNEPA by phone

1. Reviewed economic importance of project to Navajo, its lower emissions relative to other coal plants.

2. Reviewed previous ENSR & NPS modeling results; ENSR's follow-up to FLAG document procedure, and NPS's CMC modeling of potential adverse visibility impacts

3. Discussed features that refined modeling of visibility should have. Affirmed that new modeling of Class I visibility impacts probably needed, to supercede modeling done previously. This will help remove ambiguity from past modeling, give better support for whatever decisions are made.

4. ENSR/SGP to explore modeling options, including new chemistry put into CALPUFF by EarthTech

5. NPS to consider running CAMx grid model using WRAP inventory, stand-alone or to provide background for a puff/plume model such as SCICHEM (or CALPUFF?)

6. EPA to resolve several regulatory questions, e.g. FCPP increment expansion

7. Follow-up call next week, 3 pm MDT Thurs 5/12, call-in: 202/275-0166, code 7807#

- Scott B.

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DREF_mtg0503.txt ENSR_slides_May3.txt Sithe_impact_on_GC_CIRA_presentation.txt

Notes from 5/3/05 meeting on
Desert Rock Energy Facility visibility modeling
held at CIRA office, Fort Collins, CO (sjb 5/10/05)

Attendees: NPS, CIRA, EPA, DPA, Ater Wynne LLP, SGP, ENSR, NNEPA by phone
(Abbreviations at end. These notes are paraphrases, not quotes.)

Main meeting outcomes:

1. Reviewed economic importance of project to Navajo, its lower emissions relative to other coal plants.

2. Reviewed previous ENSR & NPS modeling results; ENSR's follow-up to FLAG document procedure, and NPS's CMC modeling of potential adverse visibility impacts

3. Discussed features that refined modeling of visibility should have. Affirmed that new modeling of Class I visibility impacts probably needed, to supercede modeling done previously. This will help remove ambiguity from past modeling, give better support for whatever decisions are made.

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Status

PSD permit status- Scott Bohning, EPA

- Still have not fully decided that Four Corners Power Plant (FCPP) reductions expand increment, but leaning that way. (ENSR previously indicated that may not absolutely need that expansion)
- EPA asked for IGCC in BACT analysis, to have complete record in case of probable later challenges.
- It's nearly a year after application was found complete, but EPA wants further BACT info and to satisfy FLMs on visibility if possible; could reset the "clock" if necessary.
- EPA has to make own decision as permitting authority, but required to take FLM analysis into account, gives it strong weight, need to be able to address possible FLM objection to permit and probable lawsuits challenging EPA decision

EIS status - Gus Eghneim, Woodgroup Power, for Sithe Global Power (SGP)

- SGP expects species assessments done by late summer 2005; Record of Decision (ROD) in 1st quarter for 2006

NPS: Question: Does issuing permit to source with a certain configuration bias the EIS evaluation of alternatives? (EPA will look into this)

###

Project Benefits

Steven Begay, Diné Power Authority (DPA)
- Project benefits include tax revenue, land and water use permits, salaries; may

end up being 25-35% of Navajo Nation budget.
- Especially concerned given possible shutdown of Peabody / Kayenta coal mines.

Doug MacCourt, Ater Wynne LLP
- Navajo Council established DPA to benefit Navajo people; selected STEAG, not vice versa; will help supply electricity to Navajo (30-40% lack it); may be economic life/death for Navajo.

Gus Eghneim, SGP
- DREF would set new BACT standard, e.g. 0.06 lb/MMBTU vs. 0.09 lb/MMBTU SO2, at a cost of tens of millions of dollars; pushes the envelope in other ways
- In thinking about lowering impacts; credit/consideration should be given for reductions already incorporated in project design.

###

ENSR on modeling
Bob Paine, ENSR

- Using EPA's f(RH) curves
- 24-hour average in FLAG document masks diurnal changes; worst extinction might be at night; daily average gives least numerical weight to hours with low extinction, thus discounting hours with good visibility
- suggest CALPOST method 7' to use weather observations in assessing change relative to natural background visibility
- Nitrate may be over-predicted; ammonia may be limiting factor
- For some Class I areas, organics may dominate visibility
- Project is consistent with WRAP haze rule and (tribal?) set-asides...
- Joe Scire (Earth Tech, author of CALPUFF) feels CALPUFF predicts SO4 OK on average

###

NPS on modeling
Bret Schichtel, NPS (incl. comments from Bill Malm and John Vimont)

- Need better wind flow field, better chemistry, better deposition, realistic radiative transfer model (estimates visibility from concentrations).

- CMC used as a diagnostic model to assess main features, and whether there is a problem.

Meteorology

- Have to get flow right before can hope to address visibility.

- Ideally MM5 meteorological modeling would have 1/2 - 1 km grid spacing to deal with complex terrain of the area, but 4 km scale can capture a lot.

- Tim Allen (F&WS) re-ran ENSR's CALPUFF model from PSD application, but using 12 km and 4 km winds; higher resolution led to more frequent and higher GC impacts.

- Synoptic flow is in opposite direction from flow to and in GC.

- Past modeling of haze on Colorado plateau have failed. NPS modeling using CMC is first to capture multi-day stagnation followed by drainage via San Juan River valley and to Grand Canyon; Model confirmed flow to and potential adverse impact on GC -- correlation of this flow with historical haze events.

- Polar highs occur over FCA every winter. Bad haze events in GC 3 - 5 times per winter, lasting 2 - 3 days each.

- Need better assessment of impact frequency, and of magnitude for this particular source.

Chemistry

- After flow field, improved chemistry is most important; need good prediction of sulfate (SO4) concentration to assess visibility.

- CALPUFF has simple parameterized chemistry.

- NPS used CMC model with simple SO2-to-SO4 conversion rate of 5%/hr for winter episode; this gave about 40% conversion overall by the time plume reaches GC after 4 - 8 hours, thought to be reasonable.

. Changing from 5% to 1% decreases concentrations by factor of 3.

. CALPUFF max about 3%/hr, depending on humidity, stability, etc.

. Clear skies conversion rate is about 1%/hr, nights about 0.1%/hr, in clouds nearly 100%

- Need better aqueous phase chemistry, take into account plume encounters with clouds having very high conversion rate, and the background oxidant field that enables the conversion (e.g. from a grid model).

- Clouds aren't predicted well by meteorological models; need to test sensitivity, use observations, assess frequency.

Visibility as calculated from concentrations

- FLAG document screening procedure has many compromises built into it, e.g. uses 24-hour average extinction, does not consider lines of sight; there's not much benefit to just replacing CALPUFF with a different model.

- Need more realistic radiative transfer model: look at lines of sight, layered hazes

Other - deposition and plume rise

- Need better wet and dry deposition, depending on precipitation and ground cover.

- Plume rise equations are semi-empirical, have a lot of uncertainty, therefore need sensitivity analysis to vary plume height and assess effect.

- Upper level and lower level flow are decoupled; plume rise determines which flow the plume is carried by. Lower plume rise hits GC more; higher stack hits Canyonlands and Arches more.

- Possible models: ROME/SCICHEM/CALPUFF; Eulerian grid model (latter takes roughly 4-5 days to simulate a month)

- NPS may be able to provide applicant with CAMx grid model runs using 12 km and 4 km wind fields, using WRAP 2002 inventory (use this to represent Jan 2001 that was done in CMC modeling); would take a month or so; will look into possibility,

###

Modeling & other discussion

John Notar, NPS
- CALMET switches used in DREF application seems to overemphasize upper level winds

/ synoptic scale background flow from MM5; too small a radius of influence used for observations.

ENSR: followed Joe Scire & John Irwin advice on switches.

Dirk Straussfeld, SGP
- Large SO2 reductions have occurred over the past few years; should be able to see this effect, provide a check on the model.

NPS: But meteorology also varies a lot; can get very different impacts even when emissions are constant.

Scott Bohning, EPA
- Still would like reality check of model predictions vs. observed concentrations.

SGP & EPA:
- Grid modeling would have its own uncertainties and problems. Would DREF even show up in a grid model, or would it be lost in noise? Not clear how meaningful the grid model prediction for a point source would be.

NPS: Discriminating effect of source alone is probably not a problem; incremental impact of project in a simulation of all sources is little different than simulation of project by itself, as long as there's plenty of oxidant around.

EPA
- There may be no point in new refined modeling, if we already know that impact will be higher. E.g. higher resolution wind field increases impact, and no counterbalancing decrease due to improved chemistry.
- On the other hand, more refined modeling would provide better justification, e.g. for accepting project as is or for asking for mitigation.
- Given sensitivity of Four Corners area, if don't do a refined analysis in this case, when would you ever?

NPS: Don't know overall effect of refinements discussed above will be increased impact, so new modeling still worth doing.

SGP: What is an "adverse" impact?
NPS: Determined by FLM. Various factors...

EPA: Just look at three winters, rather than three whole years?
NPS: Summer may be needed, too, USFS may want to look at summers for their Class I areas.

SGP: May be able to put stack inside of cooling tower, as is often done in Europe. This might be less costly, since wouldn't need planned 917 ft (280 m) stack. Benefit is that cooling tower adds buoyancy, get higher plume rise, and also nearby people would not have to look at huge stack.
NPS: Wouldn't this be a forbidden "artificial dispersion technique"?
EPA: will look into this.
(The higher plume rise might just shift main impact from GC to another Class I area, per above discussion, so not clear this would help much.)

EPA: would like modeling protocol from applicant. We will still have to discuss temporal and spatial scope, what model to use, accounting for natural impairment of visibility, performance evaluation... Hope to arrive at a modeling methodology we can all go along with, enable stronger more supportable decisions.

SGP/ENSR: Will look into modeling possibilities. Will look into CALPOST method 7'.

EarthTech may be able to put new aqueous phase chemistry put into CALPUFF in a matter of weeks; but needs funding to do it.
NPS: Our budgets are on a two-year cycle...

###

Abbreviations

CIRA = Cooperative Institute for Research in the Atmosphere
CMC = CAPITA Monte Carlo model, air trajectories and dispersion
DPA = Diné Power Authority
DREF = Desert Rock Energy Facility, project
ENSR = consultant to SGP
EPA = U.S. Environmental Protection Agency
f(RH) = Relative Humidity adjustment factor, to convert concentration to visibility extinction
F&WS = Fish and Wildlife Service
FCA = Four Corners Area (Arizona, Colorado, New Mexico, Utah)
FCPP = APS Four Corners Power Plant
FLAG = Federal Land Managers AQRV Workgroup
FLM = Federal Land Manager
IGCC = Integrated Gasified Combined Cycle
NNEPA = Navajo Nation Environmental Protection Agency
NPS = National Park Service
SGP = Sithe Global Power LLC, project proponent
USFS = United States Forest Service

###

Attendees

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ENSR_slides_May3.ppt
Bob Paine, ENSR

1. Review/Update
Long-Range Transport Air Dispersion Modeling for the Proposed Desert Rock Energy Facility
Bob Paine, ENSR
May 3, 2005

2. Class I Modeling Domain

3. Potential Project Emissions

Pollutant	PC Boilers (tpy)	lb/mmBtu
CO	5,526	0.10
NOx	3,315	0.06
SO2	3,315	0.06
PM (filterable)	553	0.010
PM10 (total)	1,105	0.020
VOC	166	0.003
H2SO4	221	0.004

4. Highest Modeled PSD Class I Increment Concentrations (μg/m3) Over Three Years (2001-2003)
[table from PSD application, impacts at 15 Class I areas; only 3-hr and 24-hr SO2 impacts are significant]

5. Results of Cumulative SO2 Increment Modeling
* Inventory of point sources gathered from NM, AZ, CO, UT, and tribal area
* PSD increment expansion from FCPP/SJGS (if needed for compliance at Mesa Verde) has been questioned
* This may be a moot point due to planned emission reductions at FCPP and SJGS
* Area and volume sources generally have no (or very low) SO2 emissions
* SO2 emissions from mobile sources will drop significantly with ULSD

6. FLAG, RHR, and PSD
FEDERAL LAND MANAGERS' AIR QUALITY RELATED VALUES WORKGROUP (FLAG): RESPONSE TO PUBLIC COMMENTS ON DRAFT PHASE I REPORT
"It is important to emphasize that the FLAG report is only a guidance document. It is separate from Federal regulatory programs. The scope of the FLAG report is to provide a more consistent approach for the three FLM agencies to evaluate air pollution effects on their resources, and to provide guidance to permitting authorities and permit applicants regarding necessary AQRV analyses. Although FLAG strives to be consistent with regulatory programs and initiatives such as the Regional Haze Rule and New Source Review Reform, no direct ties exist between FLAG and these regulatory requirements."

7. Regional Haze Impacts
* First conducted using FLAG screening procedures - consistent with RHR goals of achieving natural conditions
* Results showed impacts over 5% screening threshold during high RH events
* Other alternative analyses were conducted to review these high RH events
    - RHMAX = 95% - consistent with RHR
    - EPA f(RH) curves - consistent with RHR
    - Consideration of natural obscuration during these events (flagged as natural events by monitoring protocols for implementation of RHR)

8. FLAG Results, RHMAX = 98%
[table showing extinction change at 15 Class I areas; range from 5.6% to 27.4%]

9. FLAG Results, RHMAX = 95%, EPA f(RH) curves
[table showing extinction change at 15 Class I areas; range from 4.4% to 28.3%]

10. High Relative Humidity Hours can Create a False Impression for Visibility Impacts
* High RH hours cause the highest visibility impacts, all other factors being equal
* But, high RH hours are often associated with:
    - Nighttime hours with obscuration/cloud cover - pitch black conditions
    - Or, daytime hours with substantial obscuration - rain, fog
* In many cases, visibility changes during relatively clear, daytime hours is below 5%, but the FLAG method cannot report this with its daily averaging scheme

11. Diurnal Behavior of Hourly Percent Extinction Change and Relative Humidity
[graph shows Extinction Change and Relative Humidity vs. Time of Day;
- Relative Humidity just under 100% in early morning, then drops to 50%
- Extinction Change up to 120% for several hours in early morning, then drops to 10% or less
- Extinction change predicted by CALPOST is constant at 52%
]

12. Computation of Daily Extinction Changes
* Current method averages all 24 hours of natural background and source-caused extinction separately, then takes ratio
* Hours with worst visibility are heavily weighted in the total, but might often be during periods of meteorological interferences - good visibility hours have the least weight
* Method does not directly relate to the visual experience of a visitor, which varies from hour to hour

13. Alternative Method for Computing Daily Average Extinction Changes
* Compute hourly ratios of (background + source) / (background) extinction
* For hours with meteorological interference, set the ratio to 1.0 - this assumes that the source impact is negligible during these hours
* Take a geometric mean of the hourly ratios to obtain a daily mean ratio
* This method is similar to the recently-developed Method 7' that has been installed into CALPUFF

14. Results of Alternative Analysis
* Data sources investigated included radar, satellite, airports, and IMPROVE sites
* Natural interferences did influence portions of the days in question
* Review of the days with impacts over 5% showed reduction of impacts with revised calculation

15. Other Issues
* Background salt concentrations have a very minor effect and will not be considered in this case
* Highest visibility impact days occur during cold weather - nitrate predictions in CALPUFF are likely too high, perhaps by a factor of 2
* Joe Scire indicates that CALPUFF sulfate prediction evaluations (especially SW Wyoming) do not indicate any underprediction tendency, on average, in situations affected by clouds and aqueous phase chemistry

16. Area Emission Reductions
* Announced or implemented SO2, NOx, and PM10 voluntary emission reductions at SJGS and FPCC should provide an additional comfort level

17. PNM San Juan Generating Station Sulfur Dioxide (SO2) Emissions - Tons
[bar chart:
1999: 29,471
2004: 16,168
2010: 9,373
]
From http://www.pnm.com/news/docs/2005/0310_sj_so2_2.pdf

18. PNM San Juan Generating Station Nitrogen Dioxide (NO2) Emissions - Tons
[bar chart:
1999: 29,333
2004: 26,888
2010: 19,882
]
From http://www.pnm.com/news/docs/2005/0310_sj_so2_2.pdf

19. PNM San Juan Generating Station Particular Emissions - Based on Permit Levels
[bar chart:
1999: 3,356
2004: 3,454
2010: 990
]
From http://www.pnm.com/news/docs/2005/0310_sj_particulates.pdf

20. Summary of SJGS Changes
* SO2 annual emissions reduced by nearly 7000 TPY (vs. about 3300 TPY Desert Rock)
* NOx annual emissions reduced by about 7000 TPY (vs. about 3300 TPY Desert Rock)
* PM10 annual emissions reduced by nearly 2500 TPY (vs. about 1100 TPY Desert Rock)
Changes at Four Corners Power Plant
* These changes appear to be voluntary SO2 emission reductions throughout 2004 due to increased scrubbing efficiency
* Changes can be seen from data posted on the EPA's Acid Rain Database
* Annual SO2 emissions appear to be dropping from about 35000 TPY to about 15000 TPY, a drop of some 20000 TPY

21. Changes at Four Corners Power Plant
* These changes appear to be voluntary SO2 emission reductions throughout 2004 due to increased scrubbing efficiency
* Changes can be seen from data posted on the EPA’s Acid Rain Database
* Annual SO2 emissions appear to be dropping from about 35000 TPY to about 15000 TPY, a drop of some 20000 TPY

22. Mesa Verde Particulate Speciation
(default natural conditions = 5.6 Mm-1)
[table and pie chart showing extinction for aerosol components, on 20% best and 20% worst days; respectively organics account for 27% and 36%]

23. Weminuche Particulate Speciation
(default natural conditions = 5.6 Mm-1)
[table and pie chart showing extinction for aerosol components, on 20% best and 20% worst days; respectively organics account for 28% and 42%]

24. Grand Canyon Particulate Speciation
(default natural conditions = 5.5 Mm-1)
[table and pie chart showing extinction for aerosol components, on 20% best and 20% worst days; respectively organics account for 18% and 45%]

25. Canyonlands Particulate Speciation
(default natural conditions = 5.6 Mm-1)
[table and pie chart showing extinction for aerosol components, on 20% best and 20% worst days; respectively organics account for 28% and 38%]

26. Conclusions
* Proposed project has state-of-the-art emission controls.
* Most important Class I impacts are SO2 increment consumption and regional haze.
* Sulfates appear to be the most critical anthropogenic pollutant (aside from prescribed burning) at nearby Class I areas.
* Considering area emission reductions of some 27000 TPY SO2, we believe that the much smaller project emissions (3300 TPY SO2) will not cause an adverse impact.
* Proposed project is consistent with WRAP RHR SO2 Milestones and Backstop Trading Program, allowing an SO2 set-side to ensure equitable treatment for tribal economies and to prevent barriers to economic development.

Sithe impact on Grand Canyon
[converted from "Steag impact on GC CIRA presentation.ppt", 62 MB]
Bret Schichtel, NPS
5/3/05

1. Evidence of the Proposed Sithe Power Plant's SO2 Emissions Contributing to Haze in the Grand Canyon NP and other Class I Areas

2. Four Corners and Surrounding Terrain
Four Corner region is surrounded by mountains extending more than km above and can act as effective barriers to airmass transport allowing PP emission to accumulate.
Three passes exist in which trapped air in the four corner region can escape
1) Northwest along the San Juan river valley to Lake Powel and Grand Canyon
2) Southwest by the Painted Cliffs and into the Painted Desert and Petrified Forest. These airmasses could then be channeled along the Little Colorado River basin to GC
3) Southeast to Albuquerque NM

3. Grand Canyon Filling Up With Clouds
Easterly View of Grand Canyon from Desert View Watch Tower

4. Clouds in the Grand Canyon Efficiently Oxidizing SO2 gas to sulfate aerosol
Haze cooking in clouds

5. Clouds Evaporate Leaving Behind a Sulfate Haze

6. Clouds Evaporated Leaving Sulfate Haze

7. Next Day After Haze is Blown Out

8. [clouds and haze]

9. [clouds above]

10.[clouds above]

11. Layered Hazes at Multiple Parks
- Navajo Mnt as seen from Bryce Canyon (130 km)
- Looking over Canyon Lands at La Sals Mnts (haze is over and in Canyon Lands)
- Mesa Verde, CO looking at Beautiful Mountain (94 km)
- Looking at Desert View from Yavapai lookout in Grand Canyon (30 km away)

12. Elevated Nitrogen Dioxide Layers

13. Conceptual Model for Wintertime Haze in the Grand Canyon Due to Power Plants
* Pollutants are transported to the rim of the canyon or Lake Powell Region
* Drainage flow bringing the pollutants into the canyon from the rim or from the entrance at Lake Powell and can be transported throughout the length of the Grand Canyon
* Over one or two days sulfur dioxide gas is converted to particulate sulfate efficiently through wet phase chemistry in clouds.
* The clouds evaporate, leaving behind the in-canyon sulfate haze with clear sky

above the canyon.
* Human observers are particularly sensitive to the sharp changes in contrast between the boundary of the haze layer and clear sky or terrain.

14. Can emissions from the Steag Power Plants be transported to Lake Powell and into the Grand Canyon?

15. Perfluorocarbon Tracers Release During Project MOHAVE
Jan-Feb 1992, tracer was released from Dangling Rope on shore of Lake Powell

16. Dangling Rope Tracer Measured in Canyon
- February 2, 1992 - High concentrations in canyon at Marble Canyon (47 fl/l) and Indian Gardens (29 fl/l). Low concentrations at Hopi Point
- January 17 -, 1992 Concentrations throughout the canyon along the Colorado River from Lake Powell to Mohave PP

17. CAN THESE TYPE OF TRANSPORT, DISPERSION, AND CHEMICAL PROCESSES BE MODELED?
Channeled flow in complex terrain
* Drainage flow into the Grand Canyon
* Clouds and wet phase chemistry
* Layered haze: 3-dimension radiative transfer

18. Four Corners and Surrounding Terrain

Four Corner region is surrounded by mountains extending more than km above and can act as effective barriers to airmass transport allowing PP emission to accumulate.
Three passes exist in which trapped air in the four corner region can escape
1) Northwest along the San Juan river valley to Lake Powel and Grand Canyon
2) Southwest by the Painted Cliffs and into the Painted Desert and Petrified Forest. These airmasses could then be channeled along the Little Colorado River basin to GC
3) Southeast to Albuquerque NM

19. MM5 Wind Fields
* January 2-30, 2001
* 37 layers
* 36/12/4km grids
* 36km FDDA
* Established settings

20. CAPITA Monte Carlo Simulation
* CMC is a particle dispersion model that directly simulates the transport and diffusion of the power plant plume.
        - 150 particles are released every hour and advected and diffused based upon input met fields
* Met data: MM5 4 km nested in 12 km every one hour
* Plume release at
* In Mixed layer: stack height plus ~150 m
        - Variable effective stack height using plume rise eqs.
(Plume rise simulated using the empirical Briggs equations - similar to what is used in CALPUFF)

21. Plume Dispersion Simulation from Power Plants in Four Corner Region
Yellow - Existing; Blue, Green, red - Proposed Power Plants

22. See animations
1/7/2001, 1/9/2001
* Multi-day stagnation events
* Accumulated emissions transported to Lake Powell and Channeled down the Grand Canyon

23. Episodes where Four Corner power plants impacted Grand Canyon NP in January 2001

Event	Time Period	Duration (Days)
Event 1	1/8 12:00 - 1/10 12:00	2
Event 2	1/15 16:00 - 1/18 06:00	1.6
Event 3	1/22 12:00 - 1/24 12:00	2
Event 4	1/26 20:00 - 1/28 00:00	1.16

* But is it real?
    - Match transport of existing power plants in the Four Corners region into the Grand Canyon with pictures

24. Field of view of the camera at Desert View point

25. A clear day in the Grand Canyon. Airmass stagnation over the Four Corner region allows for emissions from power plants to accumulate
1/14/01 2:45

26. The plumes move into the Colorado River drainage along with stormy weather conditions.
1/15/01 8:45   1/15/01 12:00   1/16/01 12:00

27. The clouds evaporate while the power plant plumes remain over the G.C. resulting in haze in the Grand Canyon.
1/17/01 2:45

28. Next day the haze is reduced.
1/18/01 2:45

29. Grand Canyon Episode on January 23

30. Grand Canyon Haze - January 23 3 PM

31. Add Simple Chemistry to CMC Simulation
* Weight each particle based upon emissions and apply first order sulfur chemistry to each particle
* 5%/hr SO2 - SO4 Transformation rate
    - Assuming in cloud oxidation
    - In all four episodes the plumes entered the canyon imbedded in clouds
* Used typical SO2 and SO4 removal rates
    - SO2 removal rate - 1.5 %/hr
    - SO4 removal rate - 0.7%/hr

32. Adding Chemistry and Deposition To CMC Model
* Apply conservation of mass eq. to each particle
d/dt(SO2) = - (k_t2 + k_d2 + k_w2) SO2
d/dt(SO4 2-) = (k_t2) SO2 - (k_d4 + k_w4) SO4 2-
SO2(t) = SO2(0) exp -(k_t2 + k_d2 + k_w2) t
SO4(t) = ...

33. Kinetic Processes Applied to Single Airmass History
* St. Louis airmass history
* Variation of rate coefficients along trajectory, and corresponding sulfur budget.

34. Sithe Amm Sulfate Impact on Grand Canyon
Plume Release Hgt - in afternoon mixed layer (430 m)
Plume Release Hgt - Variable effective stack height (^{3}430 m)
Plume released in stable layer - plume was released at a constant effective stack height of 430 meters = 280 m stack hgt + 150 m plume rise in stable layer (stability class F)
Variable effective stack height - used standard semi-empirical plume rise equations from the REMSAD model. These are similar to those used in CALPUFF.

35. Sithe Amm Sulfate Impact on Canyonlands, UT
Plume Release Hgt - in afternoon mixed layer
Plume Release Hgt - Variable effective stack height

* The largest impact averaged over Canyonlands varies from 0.5 to 2.5 micro-g/m3.
* Concentrations in Canyonlands increases when the higher variable effective stack height is used, particularly for the episode on January 23rd

36. Sithe Amm Sulfate Impact on Arches NP, UT
Plume Release Hgt - in afternoon mixed layer
Plume Release Hgt - Variable effective stack height
* The largest impact averaged over Arches varies from 0.4 to 1.1 micro-g/m3.
* Concentrations somewhat decreases when the higher variable effective stack height is used

37. Impact of Sithe's SO2 emissions on Mesa Verde NP, CO
View of Shiprock and Beautiful Mtn, NM from Mesa Verde
Haze Free Day
December Layered Haze
Wintertime layered hazes frequently occur in the Four Corner basin obscuring views from Mesa Verde and elsewhere.

38. Impact of Sithe's SO2 emissions on Mesa Verde NP, CO
* A plume released within the afternoon mixed layer can contribute up to 1.6 μg/m3 ammonium sulfate to a layered haze
* The elevated plume often contributes little to surface concentrations in the Mesa Verde view shed
* The elevated plume can remain as a coherent plume which could be visible at plume blight
39. Maximum Sithe Contributions to Class I Areas
Maximum hourly Simulated concentration of ammonium sulfate averaged over the National Park (5%/hr conversion)

Class I area	In Mixed Layer	Variable Effective Stack Hgt
Grand Canyon NP, AZ	1.7	1.0
Canyonlands NP, UT	2.2	2.5
Arches NP, UT	1.8	1.1
Capitol Reef NP, UT	0.86	0.93
*Mesa Verde NP, CO	1.6	0.62

*Concentration average from Mesa Verde to Chuska Mtn., the Mesa Verde view shed

A 1% transformation rate instead of 5% would decrease the concentrations by about a factor of 3.

40. Can these concentrations be seen?

41. Contribution of the Maximum Amm Sulfate Concentration to Light Extinction (Haze)

42. Simulation of Grand Canyon Layered Haze due to 1 µg/m3 of Amm. Sulfate from the Sithe PP

43. Simulation of Grand Canyon Layered Haze due to 1.7 µg/m3 of Amm. Sulfate from the Sithe PP

44. Simulation of a Uniform Haze in Grand Canyon due to 1.7 µg/m3 of Amm. Sulfate from the Sithe PP

45. Simulation of a Uniform Haze in Canyonlands, UT due to 2.2 µg/m3 of Amm. Sulfate from the Sithe PP

46. Simulation of a Uniform Haze in Capitol Reef, UT due to 0.86 µg/m3 of Amm. Sulfate from the Sithe PP

47. Flag Phase II Process

Flag Phase 1 Screening Tool
Passed: ----> Done
Failed: ----> Flag Phase II

Flag Phase II: Science

- Past A.Q. Studies
- A.Q. Data
- Diagnostic Modeling

----> Identify processes causing haze events; Understand the nature of the problem

- High re. met data
- Credible A.Q. Model
- Measured Data

----> Simulate and verify model reproduces processes

----> 4-D aerosol concentrations

----> Simulate layered and uniform haze; 3-D radiative transfer model

----> Assess source impact: Analyze distribution of visibility impacts

----> Randomly vary model inputs within physical bounds

48. Alternative Models
* Regional scale modeling using Eulerian Chemical Transport Model
* Plume/Puff models with high resolution winds and credible wet/dry chemistry
  - ROME
  - SCHICHEM
  - CALPUFF

49. 4-D Eulerian Chemical Transport Model
* CTM models more comprehensively treat the processes that govern sulfate as compared to most plume models:
    - Explicit chemistry
    - Gas-phase and aq-phase oxidation
    - Treatment of clouds and precip
    - Plume dynamics

* Illustration using REMSAD and the BRAVO model set up
    - July - October, 1999
    - 36 km MM5 wind fields

50. Emissions map
Proposed 4C plants are the *only* S sources in the domain; any sulfate at a receptor is due to these three plants

All other species (e.g., NOx) in the emission inventory are left at their "normal" emission rates; maintain oxidant balance

51. Sulfate contribution from the three proposed sources to select IMPROVE sites

52. Other Plume Model

ROME
SCICHEM
CALPUFF

53. Other Plume Models - ROME
Reactive Optics Model for Emissions (ROME)
- Reactive plume model for transport over complex terrain with intermittent cloud interactions
- Estimates point source contributions to ambient concentrations, deposition, and visibility
- Includes plume dynamics, chemistry (gas, particle, aqueous), aerosol formation, visual effects, and removal
- Description: J. Air Waste Manage. Assoc., 47, 176-184, 1997. Distributed by EPRI (N. Kumar). Manual exists, no free support. AER developed a user interface.
- Plume model: in adequate for long range transport

54. Other Plume Models - SCICHEM
Second-order Closure Integrated PUFF Model with CHEMistry (SCICHEM)
- Chemically reactive version of SCIPUFF).
- Non-linear chemical reactions in overlapping 3-D puffs, wet chem.
- Applicable to short or long distances - originally designed as a PiG
- Inorganic chemistry & particle formation superior to CALPUFF, includes SOA formation & aqueous phase chemistry. (Tombach)
- Description: Karamchandani et al., (2000) Development and evaluation of a state-of-the-science reactive plume model, Environ, Sci. Tech., 34, 870-880. (also EPRI model)

55. CALPUFF Using High Resolution Winds
* Simulations from January 2-30, 2001
* Used same CALPUFF setting as ENSR
* No wet phase chemistry
* No layered haze radiative transfer model

56. END

57.ENSR's Initial Regional Haze FLAG Results
[table from PSD application]

]
58. Src Inputs for REMSAD simulation
[table of emissions and stack parameters for BHP, Mustang, STEAG]

59. Studies of Air Quality on Colorado Plateau
* Winter Haze Intensive Tracer Experiment (WHITEX) January and February 1987
- Evaluate the feasibility of attributing single point source emissions to visibility impairment in Grand Canyon NP
* Measurement of Haze and Visual Effects (MOHAVE). Jan-Feb, Jul-Aug 1992
- Estimate the contributions of the Mohave power plant (MPP) and other large pollution emission sources to haze at the Grand Canyon and other national parks.

60. Principal Findings
* Large power plants, i.e. Mohave power plant, located west of the GCNP, and the Navajo generating station, located east of the GCNP, could significantly contribute to haze in GCNP
* Power plants located east of the GCNP are most likely to have significant impacts in the winter months
* Due to the complex terrain and important micrometeorological processes, modeling the impact of power plants on the Grand Canyon was particularly challenging and no model was able to properly reproduce all of the relevant processes of a haze episode.

61. Photographic documentation of the development of a haze episode in the Grand Canyon during WHITEX