WRAP Dust Emissions Joint Forum Meeting
February 24-25, 2004
Desert Research Institute
Las Vegas, Nevada

Notes Courtesy of Lee Gribovicz with additions from Tom Moore's notes at the end of the meeting.

Meeting Summary

On February 24-25, 2004, I attended a meeting of the WRAP Dust Emissions Joint Forum (DEJF) held in Las Vegas, Nevada. The purpose of this meeting was to go over the status of projects that the DEJF is undertaking in 2004:

- ✔ Establish a Common Definition of Dust & a Natural/Anthropogenic Split
- ✔ Develop a Handbook and Website Resource for Compiling Contemporary Knowledge of Fugitive Dust
- ✔ Improve Estimates of the Fine Fraction ($PM_{2.5}$) of Dust Emission Factors
- ✔ Examine the 20% Worst Visibility Days for Frequency and Magnitude of Dust Impacts and Their Probable Sources at WRAP Class I Areas
- ✔ Refine the WRAP's Windblown Dust Model & Produce a 2002 Emission Inventory

..... and to hear other issues of concerned stakeholders:

- ✔ Methods for Estimating Roadway Dust Emissions
- ✔ Transportation Conformity PM-Related Issues
- ✔ Satellite Imaging and GIS Mapping for Identifying Dust Sources

The Agenda for this meeting is attached under Appendix I of this memo, while Appendix II contains a copy of the sign-up sheet of attendees for this February 24-25th meeting.

Meeting Details

★ Overview of Methods for Estimating Roadway Dust Emissions ★

Rodney Langston, a Clark County Road planner gave an Overview of the current state of current AP-42 PM emissions calculations from paved & unpaved roads, and followed that with a discussion of "active" monitoring efforts which more clearly define the ***spatial*** and ***temporal variations*** inherent in road dust emission data (Appendix III). The current EPA algorithm assumes that every car on paved roads generates the same dust emissions. But there is a variation of silt content over time on roads, and a basic concern revolves around reservoir depletion vs reservoir charging rates.

Mr. Langston presented the emission formula for road dust from AP-42 which varies primarily due to differences in silt content. He pointed out that Silt Loading Measurements must be collected manually, a process which requires lane closures and is a very costly process, leading to a very limited amount of sampling data. And the AP-42 algorithm assumes a stable level of silt loading for a given road type and activity level, which according to him, is a physical impossibility.

And he pointed out that speed not accounted for at all in the current AP-42 algorithm. He noted that although speed is a huge factor affecting the PM

road dust emission rate, the current algorithm assumes constant emissions all the way from 10 to 55 mph.

He then described some alternative Vehicle Mounted Assessment Systems that are being pursued by DRI, and at UC-Riverside. The DRI system has samplers mounted directly on the vehicle, while the UCR system has sampling equipment mounted on a trailer (see Appendix for detail). He noted that the UCR system showed emissions about **a** lower than AP-42 predicted.

He felt that this type of sampling was an effective tool for evaluating the effectiveness of control measure such as Street Sweeping, Track Out Control Road Improvements and etc.

Carrie McDougall indicated that Clark County will stage a competitive "Drive Off" of the available sampling systems in the near future. The intent of the effort is to tie this type of active sampling to events such as rain and construction. They will seek EPA approval of selected system as an alternative method to AP-42 for determining road dust emissions.

The issue was raised about whether this work is really more focused on nonattainment, rather than focusing on the WRAP mandate of Regional Haze issues. I will seek TOC direction on this question and whether the Forum should be expending resources in this area of investigation.

★ Transportation Conformity PM-Related Issues ★

Susan Hardy then gave a presentation on Transportation Conformity PM issues (Appendix IV). She noted that she represents the Mountainland Association of Governments as the Metropolitan Planning Organization (MPO) for the Utah Valley Metropolitan Area Boundary (Provo/Orem). She noted that the Transportation Equity Act for the 21st Century (TEA-21) and the Clean Air Act Amendments of 1990 require the MPO's to develop both a long-range regional transportation plan (LRP) and a short-range transportation improvement program (TIP) that conform with the applicable SIP air quality plans. She explained that projections for NO_x from mobile vehicles are dropping, but the projections for mobile road dust show an approximate doubling of PM emissions from that category between now and 2030.

She made the point that her MPO emission calculations currently show a 49% road dust, salt & sanding contribution to ***emissions***, but the modeling of the "design day" value of 254 :g/m³, showed that road dust, salt & sanding contribution was only about 1.9% of the total to the ***ambient concentration***, or 4.8 :g/m³. Her basic position is that road dust emissions aren't as big a portion of the process as the EPA models seem to indicate, and control strategies for road dust may not result in as significant improvement to actual ambient concentrations as envisioned.

The question was raised as to whether the DEJF wanted tackle the correction of AP-42, and I suggested that it seemed like a lot of the problem had to do with EPA mobile models (MOBILE & NONROAD) and dispersion factors (divide by 4), which don't seem central to the WRAP's mission of getting a quality §308 dust inventory. Tom Moore pointed out that we already have road dust inventories, and the question may be whether the DEJF is comfortable with those specific inventories.

★ Definition of Anthropogenic vs. Natural PM Sources ★

Rob Farber is leading this project, and he had prepared a DRAFT template for Forum comment on the Definition of Dust and the Natural/Anthropogenic split. The DRAFT definition for "fugitive dust" was discussed, and finally amended to be, **"dust that enters the atmosphere without first passing through a vent, duct, stack or tailpipe"**.

Then there was a discussion on the more general definition of "dust". Mobile tailpipe PM emissions were initially included in this definition, but I and other members of the Forum strongly objected to including tailpipe emissions as dust. The conclusion was to drop tailpipe emissions from the approach to the dust question. There was discussion about whether certain other materials were "dust", such as sea salt and skin flakes. The point was made that some suspended particulate might be "alive", such as mold or viruses. A more general concern was biologic material such as pollen. There was discussion about whether to include in the dust definition some sort of size criteria, like a PM_{10} and $PM_{2.5}$ limit. There was discussion as to whether moisture was part of dust.

The working definition adopted for dust is **"Particulate matter that can be suspended into the atmosphere as a result of mechanical, explosive, or wind-blown suspension of organic, geologic or synthetic solids, excluding mold"**.

The next issue raised was the definition of Anthropogenic vs. Natural dust, and the initial categorization scheme is shown below:

	Reasonably Controllable	Largely Uncontrollable
Anthropogenic	Type I	Type II
Natural	Type III	Type IV

There were questions about whether certain sources of dust, such as a "natural" volcanic eruption, but the ash is left on streets to be re-suspended by human activity (ie/ driving). Another example was the case of an off-road vehicle breaking the crust on desert soil, which subsequently allows significant dust from wind erosion. Or how would you classify a dry lake bed which was drained by human water diversion? If that lake was dry due to drought conditions, then it would clearly be natural, but with human intercession, does that now make it anthropogenic? Other examples of perplexing questions include: dust from wind erosion from over-grazed lands, or international transport of China dust storms caused by poor farming and soil conservation techniques.

Tom posited that we may be looking at what the origin of the emissions are as our starting point for defining anthropogenic, and not what these emission later become. I noted that there will be innumerable examples of dust situations, and unending debate as to what the "causes" were. I suggested that this Forum is only a microcosm of the WRAP stakeholders, and we eventually will have to bring in the larger WRAP audience to get some sort of

consensus. And thus, the Forum should be working toward some sort of workshop, based on an initial premise.

The issue of "controllability" was raised, and I noted that you don't HAVE TO control natural sources, but you have to define them to set the ultimate baseline for the RH 2064 goal. But in developing strategies, you have considerable freedom to incorporate control measures for both anthropogenic and natural sources of dust.

Regarding international emissions, it was generally concluded that even though America can't "control" these sources, that fact alone doesn't make them natural. International doesn't necessarily equate to natural. But Dale Gillette pointed out that Gobi and Saharan international dust probably is natural.

The question of organics was raised, and it was noted that the IMPROVE methodology only includes geologic sources as "dust", while organics are analyzed as a separate constituent. But it was also pointed out that organic materials in the soil can certainly be part of the dust.

A table was begun with suggestions on classification:

ANTHROPOGENIC	NATURAL
all mechanically suspended dust - construction activities - road dust - etc.	volcanoes, sea salt, etc.
windblown dust from areas disturbed or altered by humans, beyond a natural range of conditions - Owens Lake - some rangeland - etc.	windblown dust from undisturbed or naturally disturbed areas - Great Sand Dunes NP
natural sources more than 12-24 months old, similar to EPA natural events policy - re-suspended volcanic ash - re-suspended wildfire ash	

Next Steps - Refine this discussion into some type of "position paper". Then circulate it to the DEJF. When the forum reaches a consensus, then it will go to the oversight committees. Then a decision needs to made about some sort of WRAP wide forum, before finally being taken before the Board.

★ Dust Handbook ★

We have 6 proposals (Mactec, Sonoma, Countess Environmental & MRI, Trinity, Environ & ERG, and Sierra Research), and the Bid Review Team (Wayne Leipold, Ed Berry, Lee Alter, Carrie MacDougall, Toni Richards & Duane Ono) will interview these bidders, first by phone. They plan on completing the selection and beginning work on the product in the next month. The selection

committee was given the endorsement of their final decision, without bringing the matter back for full Forum consideration.

There was discussion on what the handbook will contain, and generally the Forum concluded that the consultant will bring together a compendium of the information that is available. It was concluded that it would be inappropriate for the Forum to "pass judgement" on the efficacy of the information that is included in the compendium.

★ Fine Fraction of Dust ★

Roger Isom is the lead on this project, but since he was unavailable, Duane Ono discussed this project (Appendix V contains a problem statement and project description). The problem is that initial $PM_{2.5}$ cascade impactor monitoring allowed larger particles to "bounce" down to the final 2.5: filter, resulting in an inflated concentration attributed to $PM_{2.5}$. The EPA eventually corrected the reference method (greased plates), but it is still felt that the AP-42 factors for $PM_{2.5}$ are problematic.

This DEJF project is intended to generate a known inlet concentration of $PM_{2.5}/PM_{10}$ particulate from various geologic sources, monitor this known concentration with the cascade impactor reference method, and use the results to refine the fine fraction measurements and $PM_{2.5}/PM_{10}$ ratio (currently estimated at 22% $PM_{2.5}$). Duane is planning to have the WRAP issue a sole-source contract to Midwest Research Institute (MRI - Chat Cowherd), the organization that originally completed the monitoring test work.

The question was raised as to whether other entities might not be contacted to help fund this effort, considering the information will be useful to the general air pollution community. Don Arkell also made the point that there needs to be a very clear, concise explanation as to why the states/tribes benefit from this project.

A workgroup was established for the project, consisting of Rob Farber, Barbara Trost, Bruce Friedl, Gail Cooke, Duane Ono, Roger Isom, Don Arkell, and Jean-Paul Huys.

★ Satellite Images and GIS Mapping ★

Rob Farber of Southern California Edison was a participant in a study to develop an automated system to identify non-crusting "blow sands" that are continuous emitters. The attached report (Appendix VI) notes that it is important to identify and control these "blow sands" as a significant component of an overall dust mitigation effort. It describes how they used an "ER Mapper 6.3" software package that uses Landsat 5 TN multispectral satellite images and GIS mapping to identify these areas. It then describes how emissions are quantified from the blow sand areas by monitoring the saltation and erosion of these areas.

★ 20% Worst Visibility Days for Dust Impacts ★

Vic Etyemizian gave a presentation, beginning with a map of the 1997 and 2002 IMPROVE monitoring network, which shows a great increase in sites in the latter configuration. This was a result of the EPA's initiative to fund an increase in monitoring for RH and $PM_{2.5}$. He then showed the equation for $\$_{ext}$,

composed of sulfate (SO_4), nitrate (NO_3) , Organic mass by Carbon (OMC), Light Absorbing Carbon (LAC = elemental carbon), fine soil(FS $\leq$ 2.5 :) , and coarse mass (CM = PM_{10} - $PM_{2.5}$). And he described the 20% Worst Days as: "the days with light extinction coefficients above the 80th percentile value". Dust is defined under the IMPROVE protocol as the ***sum of CM + FS***. He compiled a list of sources of dust which included:

- Regional Windblown
- Local Windblown
- Road Dust
- Construction
- Mining
- Agriculture
- Other
- Asian Origin
- African Origin
- Organic debris
- Wildfires
- Volcanoes
- Sea spray

He showed maps (Appendix VII) of the fractional contribution of dust to extinction on the 20% worst days (red > 50%), the fraction of 20% worst days when dust contributed significantly (15% or more) to extinction, and the fraction of 20% worst days when dust contributed more than any other component (NO_3, SO_4, OMC, LAC) to extinction (both red > 80%). They all show that dust "problems" are centered around Arizona, with marginal areas extending into southern Nevada, Utah, Colorado and western New Mexico.

He showed several examples of "haze-agon" analysis of several high dust sampling days (presence of a haze-agon indicates that day was one of the 20% worst days at that site, and the six sectors of the haze-agon indicate which of the six visibility components dominated impairment on that day).

On April 26, 2002, CM dominated in the Arizona region, while SO_4 dominated in the Pacific Northwest. An Asian dust storm occurred on April 16, 2001, where both CM and FS were "significant" (10-40%) throughout the west. On July 27, 2001, there was a "localized" dust storm in Montana, where other regional IMPROVE sites were unaffected. Then on August 17, 2001, the haze-agon plots confirm problems with OMC throughout the Pacific Northwest due to wildfire activity.

From these examples, Dr. Etyemizian discussed the types of analyses that could be done to evaluate dust contribution from the data sets. There are expensive and resource intensive analyses that can be done for EACH sample. But a more semi-systematic method would look closely at a subset of worst days with dust as a dominant source. Then we would find commonalities among “like” events and differences between “unlike” events. Using a set of criteria, we would then place all remaining worst days into one of several categories according to “most likely source type”.

To do this for local and regional windblown dust, we should first identify a nearby meteorological station that can provide reasonably representative wind speed data. Then we should look at wind speed vs coarse mass to estimate a threshold value for windblown dust at that site. On worst days when dust is a dominant haze component, we then should see *if the threshold value is exceeded and if the CM/FS ratio is above a predetermined value*. If so, then we would ***categorize*** that incident **as Windblown Dust**.

For **Asian Dust** there is a tendency that this will have large regional influence. Therefore we would compare the CM/FS ratio to a predetermined

value (nominally 1 or less means long-range transport), and inspect the chemical signature (K/Fe, Al/Si). We would identify a possible corresponding Asian Dust Event (using the NRL model) and inspect air mass trajectories. Then it would be fairly conclusive whether the data all points to Asian origin. Determining **African Dust** would follow the same type of procedure.

For **Construction**, unless there is a project close to the monitor this would be an infrequent occurrence. It would be difficult to identify unless the activity is well documented. The same applies to **Road Dust**. For **Mines**, there has to be a determination whether there is a facility within one day's transport, and the wind trajectories have to confirm that the dust could have come from that facility. For **Agriculture**, dust could be substantial, depending on season. It is relatively difficult to confirm individual event occurrences (ie/ Did Farm X harvest almond on Date Y?). **Organic debris** can be related to agriculture, is probably seasonal, and probably shows different CM/FS ratio than windblown dust. For **Wildfires and Volcanoes**, it should be fairly obvious whether there ere there any wildfires or volcano eruptions nearby. Ratios of FS/OMC, K/FS and CM/FS can help. Regarding **Sea Salt**, that is probably limited to coastal sites. Na & Cl content, and CM/FS ratio can help identify this source.

This method would consider only 2001-2003 data on 20% worst days at WRAP sites where dust (CM+FS) is the dominant haze constituent. We would then categorize the ~899 site-days, according to reasonable criteria, into:

- International (Asian, African, Mexican)
- Regional (multiple sites)
- Local (1-2 sites)
- Fire (smoke mis-classified as dust or entrained by turbulence
- Unknown (some combination of above, or other source(s))

For each category we would look at trajectories, chemical composition and related data sets. For some days in each category, we would have to provide more in-depth descriptive information.

There was discussion as to whether the "Causes of Haze" budget allows this type of analysis. Marc Pitchford thought that the DRI staff currently dedicated to the Causes of Haze effort wasn't currently sufficient to do all the work, but the DEJF has $50K to look at this question. It was decided that DRI would write a proposal to conduct the analysis, and a subcommittee of Marc Pitchford, Rob Farber, John-Paul Huys & Bruce Friedl will review this project.

★ Windblown Dust Inventory ★

Tom Moore noted that Environ conducted a Phase I of the project to develop the model and process it for a 1996 windblown inventory. But there are some concerns over the adequacy of input data, and there needs to be refinement of the results. But the WRAP needs to "lock down" 2002 inventories in about August '04. Therefore the DEJF needs to look at the current results and decide exactly what needs to be done quickly. Phase II of the project will be carried out through the Regional Modeling Center, with Environ as the responsible subcontractor.

Gerry Mansell then presented the history of the project and described the information sources used to develop the model. He noted that the methodology

was intended to utilize emission factors derived from wind tunnel studies for specific land types, in coordination with detailed maps of land use categorization and specific year meteorology, to calculate hour by hour estimates of windblown dust emissions throughout the WRAP region.

He then reviewed the data that was utilized in the Phase I project. This includes:

Land Use/Land Cover (LULC)
- Biogenic Emission Landcover Database (BELD3)
- North American Land Cover Characteristics
- National Land Cover Database (NLCD)

Soils Characteristics
- State Soil Geographic Database (STATSGO)
- Soil Landscape of Canada (SLC_V2)
- International Soil Reference and Information Center

Meteorological Data
- 1996 MM5 36-km (Wind Velocity, Precipitation, Snow/Ice, Soil Temperature)

For the project, the land use and soil texture data was aggregated to a 12 KM grid. Major land use categories include: Urban, Agricultural, Forest, Shrub & Grasslands, and Barren & Desert.

Assumptions that were used are contained in Environ's October 22, 2003 memo. These resulted in unusually high PM emissions, so they made some "Sensitivity Adjustments". They reduced the threshold wind velocity to 15 mph (they never completed the run using a 5 MPH threshold because the extensive calculations slowed the model processing to a glacial pace), and they relaxed reservoir recharge assumptions (12 hours between wind events, 36 hours after rain events, 36 hours after snow/ice meltdown & 6 hours after thaw). The changes showed significantly greater PM_{10} from the Sensitivity Run than from the results using the original assumptions. Appendix VIII contains a graph of PM_{10} by month comparison between the two methods & a spatial map showing the differences the sensitivity assumptions make in annual emissions.

They also did a completed application to the Imperial Valley of California. They used a 2 KM grid modeling domain, CALMET meteorology (15 mph threshold), 2 different sets of LULC data (BELD3 & Dept. Water Resources-DWR), and the same recharge assumptions described above. The BELD data showed significantly higher emissions.

Then the RMC ran the CMAQ model with dust emissions from the original assumptions run and compared the values with results from a run w/o any windblown dust (Basei run). The model showed higher CM & FS concentrations with the fugitive dust included, but CMAQ tends to over-predict these components even without the increased windblown dust added due to the sensitivity assumptions.

Environ's recommendations include:

- Methodology review and refinement
- Current, detailed data to characterize vacant lands
- Methodology validation with small-scale, high resolution domain
- Identification and evaluation of additional wind tunnel studies

- Application to other domains/years

★ Windblown Dust Inventory Discussions ★

Michael Uhl led off this discussion with a presentation on ideas for Phase II of the project (Appendix IX). He reiterated the details of Phase I, noting that the goals were to: 1) develop a general methodology ("MacDougall Method") and program code for estimating fugitive dust emissions from wind erosion; and 2) to develop 1996 $PM_{2.5}$ and PM_{10} emissions inventories for the WRAP region modeling domain.

The Phase II goal is simply to "improve" on the Phase I model, and to provide updated 2002 annual $PM_{2.5}$ and PM_{10} EI's. Additionally, to help determine what and when control strategies should be applied, as well as to determine the visibility improvement resulting from these control strategies, the model would produce $PM_{2.5}$ and PM_{10} EI's for the 20% WORST days. The refined specifications would include:

- Apply calendar year 2002 meteorological hour-by-hour data at 12km X 12km resolution.

- Apply more current land-use data at 12km X 12km resolution, based on 1km X 1km resolution data.

- Run CMAQ with the chemistry turned off for dust sensitivity analyses

- CMAQ will determine mixing height based on MM5 input.

- Emissions will be calculated in the first boundary layer.

- Inventories will be generated for the WRAP Modeling Domain

Tasks to be completed include:

- refine the emissions algorithm
- re-grid the model to match the unified RPO national grid
- review the $PM_{2.5}/PM_{10}$ 22% ratio and adjust if necessary
- obtain new/improved land use data
- look at friction velocity, rather than threshold wind speed
- look at differences in emissions by vegetation type (data available?)
- look at surface roughness factors

★ Future Calls & Meetings ★

In the future the time set for the DEJF calls will be moved to the fourth Tuesday of each month @ 11 Mountain Time.

For the next meeting, the DEJF will look to hold the meeting in Spokane, Washington, which will allow Candis Claiborne and the University of Washington to demonstrate wind tunnel studies. The time frame will be set some time in late June or July.

★ The Remaining Group Continued Discussions on the next steps for WB Dust ★

There was discussion by Dale Gillette on changes that should be made in the model to account for differences in the threshold velocity caused by different surface roughness (Z_0) factors for bare and vegetated surfaces. Other changes were also discussed. Duane Ono gave a Powerpoint presentation which showed significant differences between the fugitive dust model PM-10 emission estimates and the emissions that were measured on a sand dune. We will try to improve the wind blown dust emission algorithm in the next phase of the project.

Next Steps for WB Dust Project:

- Friction velocities (from Z_0) as determined from soil or vegetation
  - For barren soils (< about 10% vegetation cover), threshold friction velocities must be developed using soil considerations
  - For vegetated soils (>10% cover), threshold friction velocities must be developed using vegetation considerations (from Z_0)
  - Level of disturbance = % of expected highly disturbed surfaces (unpaved roads, agricultural fields per existing activity data, dry lakebeds,etc.) of each grid cell

- New/improved land use data

- Re-grid to unified RPO modeling grid, west of Mississippi River, most of the region will be at 12km, using 1km land use data

- Look at 22% $PM_{2.5}$ of PM_{10} factor

- Sensitivity runs using Duane's method, based on modeling protocol, specifying performance evaluation metrics
  - Smaller scale
  - CALPUFF subcontract with MFG
  - 3 to 5 areas throughout WRAP region (5 soil classifications in model, climate, ecosystem as criteria)

- CMAQ inputs - computational limitations

- Task: Parameterize/optimize performance on 20% worst days for 3-5 test cases