June 12, 2002

MEMORANDUM

SUBJECT: Air Monitoring Network Assessments

FROM: J. David Mobley, Acting Director
Emissions, Monitoring, and Analysis Division (C304-02)

TO: Addressees

One of the key elements of the National Air Monitoring Strategy is the work that Regions are doing with their State, local, and Tribal agencies to evaluate their existing air monitoring programs. These network assessments are important for meeting both the short- and long-term goals for continuing to improve how we manage the air quality monitoring program. Initially, these assessments are important so that we have a good understanding of the current picture and how to make some immediate changes, where necessary, to realign the monitoring program's focus toward the priorities on ozone, $PM_{2.5}$, and air toxics monitoring, and public data reporting for each of these areas.

I have requested that each Region prepare draft network assessments by September 30, 2002, with final network assessments by March 1, 2003. The time between October and March may be necessary to build the support to implement any network changes. A draft guidance document for conducting network assessments is available on our Internet site at www.epa.gov/ttn/amtic under the National Air Monitoring Strategy section. We will continue to work with your programs throughout this period. Please contact me at 919-541-4676, if I can be of assistance in this important work.

Addressees:
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Director, Environmental Planning and Protection Division, Region II
Director, Air Protection Division, Region III
Director, Air, Pesticides, and Toxics Management Division, Region IV
Acting Director, Air and Radiation Division, Region V
Director, Multimedia Planning and Permitting Division, Region VI

Director, Air, RCRA and Toxics Division, Region VII
Director, Air and Radiation Program, Region VIII
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Director, Science & Ecosystems Support Division, Region IV
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**Network Assessment Technical Guidance - DRAFT 2/28/02**

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# I. Goals and Objectives for Conducting Network Assessments

## A. Introduction and Relationship to the National Monitoring Strategy

The EPA and State, local and tribal air monitoring agencies began developing a National Air Monitoring Strategy in 2000 at the urging of EPA. The genesis for the strategy came as a result of concerns about the increasing needs for air quality monitoring data for certain applications, and the pressure of these needs upon the available air monitoring resources. During this same period, the PM2.5 monitoring program deployment was nearing completion and it became evident that monitoring resources had been stretched to their maximum. Complicating this picture was the air toxics program which was looming as another air quality data need that was not being fulfilled. EPA began devoting more effort to examine the existing networks and their supporting mechanisms such as regulations, program priorities, and technologies.

EPA recognizes that some of the regulatory requirements that have remained in 40 CFR 58 for many years should be revised to reflect current program needs. The emission source distributions and levels for certain criteria pollutants, such as sulfur dioxide and carbon monoxide, have changed through the most recent years. The geographic extent of U.S. population growth into sprawling suburbs should also be taken into consideration for those parts of the network that are investigating population exposure types of monitoring. There are many reasons why EPA and its partners in the State, local and tribal agencies must continue to assess and where necessary, modify the air pollution monitoring networks to reflect our changing environment. Network assessments are the key to implementing the national monitoring strategy and to ensuring that the monitoring community uses its resources most effectively.

EPA conducted a national network assessment to start the investigation process. This national-level analysis, while informative in a general sense, was clearly not enough. The concerns of State, local, and tribal agencies could not be adequately taken into account by looking at the program's focus at a national level. This document is an attempt to prepare preliminary technical guidance for the monitoring community on some possible approaches for conducting localized network assessments. This document does not list all possible assessment methods, but it should help begin the process. This document can be expanded as newer tools are developed for this work.

## B. Beginning the Process

Before beginning a review of the various approaches for network assessments, it is important to understand what is considered a network assessment and how this work might vary from what is currently done in the network review process.

The bulk of the ***network reviews*** that OAQPS has seen include a description of an agency's air monitoring program, specifically, which pollutants are measured in which locations, what changes to sites have taken place over the most recent year(s), what new sites may need to be installed due to new requirements or losing site leases, and how these networks compare against the national air monitoring regulatory requirements for the criteria pollutants and PAMS requirements. Information on the siting criteria inspections, technical systems audits, and other quality control work is often provided in this annual network review. In some situations, agencies provide information on the size and scope of their network in the form of a printout from the Aerometric Information Retrieval System (AIRS), and in other cases, a report with maps and emissions figures are also included. The network review reporting format varies by Region and even within a Region, with the larger and more sophisticated State and local air monitoring agencies providing more detail on their networks than smaller agencies that may provide a short letter.

EPA's intention is to make the ***network assessment*** process build upon some elements of the network review by taking a more involved approach that includes reviewing the data collected by the network, discussing data needs with those who are supported by the program, and considering what level of performance can be achieved by the agency. The network assessment may be most effectively illustrated by considering the questions that should be considered.

-What are the various data collection objectives that a network should meet, at the national and local levels? EPA will revise the existing 40 CFR 58 to bring the monitoring regulations more in line with national data needs; however, Regions must also consider what policy decisions must be supported in addition to the national requirements. An example would include maintenance area monitoring requirements that are part of existing State implementation plans.

-What air pollutants are being measured and in what locations? Are the "correct" pollutants being measured in the best available locations to meet the national and State/local/tribal data needs? Does the network meet the national regulatory requirements? Are there additional State or local agency requirements that must also be addressed, and does the monitoring system meet these additional requirements?

-What data needs cannot be met due to limits in my budget/resources? It is important to understand both what can be provided by an ambient air monitoring network, and what cannot based upon existing resources.

-Are there monitors or sites in the network that would be more effectively located, or should any be removed? There are some arguments that suggest that removing samplers from a site does not save substantial resources. While it is true that the remaining monitors at that site would need to be maintained, removing unnecessary monitors would save on operator time at that site, possibly on the number of quality assurance audits, and on data management and validation.

-Are any environmental studies taking place in a monitoring agency's area that have a need for the ambient data? How can these additional data interests be supported within available budgets? This support may vary from reconfiguring sites or collection schedules to simply making data available.

-Is the network providing data that are suitable in terms of their quality for the program needs? Are there areas where a monitoring agency needs to improve on performance? Has there been sufficient efforts to conduct technical systems audits, site inspections, and other quality assurance and quality control activities?

-Are there other data sources such as the regional haze program's IMPROVE network, the National Atmospheric Deposition Program (NADP), the Clean Air Status and Trends Network (CASTNet), or special purpose monitoring networks that may be useful to meet the agencies' data needs? Similarly, how does the State, local, and tribal agency network support these programs? Is the monitoring network design in the Region taking full advantage of these other governmental networks?

-Are there any international boundary issues that should be supported with data from this agency(ies)'s network? Should the network be modified to support these concerns?

-Does the network employ the most effective technical methods for data gathering and management? Are the monitors in use the most appropriate? Are the data management and transmission systems sophisticated enough to support remote data access or public reporting?

## C. Roles, Responsibilities, and Network Assessment Schedules

As discussed briefly in the introduction, localized network assessments must be conducted in order for the network assessment process to be meaningful and achievable. OAQPS expects that each Regional Office will lead efforts among their State, local, and where applicable, tribal air monitoring agencies for network assessments. OAQPS will provide support and guidance when requested; however, the Regions are primarily responsible for the State and local air monitoring stations (SLAMS) networks and for the policy actions that stem from these data.

The Regions may choose to implement their network assessments over their entire geographic region by working with their monitoring agencies as a group, or individually. If the latter approach is taken, it is important that the Region consider monitoring in adjacent States or local areas that may produce data that are useful for informing a more localized assessment or data need. Both ozone and fine particles appear to drive many of the regulatory data needs; therefore, it makes technical sense that a regional approach is reasonable. OAQPS recognizes that many other factors will contribute to a Region's decision on how to most appropriately conduct their network assessments, and offers flexibility to the Regions in making this decision.

OAQPS requests that initial network assessments for the entire country be completed this year to start the process. Initial network assessment drafts should be provided by October 2002 from each Region to OAQPS. EPA does not expect that these initial draft assessments will have undergone the needed consensus building process by October; however, it is important that some effort take place this year. OAQPS expects that between October 2002 and February 2003 that Regions, States, locals, and tribal agencies will refine these initial draft assessments and complete a final network assessment by March 2003. These final network assessments should consider the technical data needs, some of the logistical requirements for making the network changes, policy implications for any network changes, and of course, resource implications for making identified changes. Full consideration for how network changes may be realized will occur throughout 2003 as the networks are modified.

The OAQPS will review both the draft and final network assessments for national consistency issues in November 2002 and April 2003, respectively. OAQPS does not expect that each Region or monitoring agency will take necessarily the same approach toward conducting network assessments. There are a variety of approaches that could be foreseen that are equally valid. The OAQPS review will focus on the end results of these assessments and how they answer the questions listed above.

As for ongoing network assessments, OAQPS suggests a 5-year cycle for full network assessments. As with the initial assessments, the Region may choose to conduct these assessments at one time for the entire Region, or on a rotational basis. Conducting full network assessments annually is too large a burden, and not truly appropriate given that our NAAQS are generally multi-year standards that require multiple years of data at individual sites. Many locations of the country experience air pollution episodes on a periodic basis, for example, every 3 to 4 years. Reviewing network performance and data over multiple years is a more robust way to assessing the network. OAQPS also recognizes that emission changes due to increasing controls are not likely to occur in a single year, and revisiting the networks over a longer period is warranted.

OAQPS intends to propose in upcoming regulatory changes that network assessments be added as a requirement. It will be important to also update language on annual reporting and certifications to reduce burden in these areas and to make better use of newer data management systems that eliminate the need for lengthy certification reports. OAQPS also proposes that deviations from national monitoring requirements are allowed for those agencies that participate in conducting an appropriate and approved network assessment that demonstrates that their alternative network meets the national needs as well as their own local needs.

## II. Technical Tools & Current Approaches

Regions and States can use any technically appropriate analytic tool or technique for their network assessments. They are encouraged to use multiple approaches. Similar results from different techniques can strengthen a case for reduced or redistributed monitoring, however, contrasting results may also be illuminating. Different approaches may yield different results because each approach probably has a slightly different objective/goal. Studying the different approaches and results will lead to a greater understanding of the various objectives and therefore lead to a network assessment most appropriate for the Region and/or State.

Several recently applied network assessment techniques, including the 'National Assessment' approach and various Regional methods, are described below. Some techniques and tools still under development are also noted. The intent of this list is not to provide all the details, rather to provide overview and motivation for the various techniques. Web links and/or contact information are provided in order for interested parties to obtain additional information. This is not an exhaustive list of methods. Also, the techniques listed below are provided for reference only. Regions / States can use these techniques, however, some may not be applicable to all areas or networks. Whatever techniques/tools are used, there should be a clear connection between the analytic results and the proposed network changes. Periodic updates to this document will highlight progress with the evolving methods and document additional illustrative Regional efforts.

### A. National Assessment:

A National assessment of the criteria monitoring networks was completed in June 2001. The assessment consisted of three distinct parts: 1) an evaluation of measured concentrations as a percentage of the NAAQS, 2) a multi objective 'information value' ranking scheme which shows the relative value of each monitor according to different monitoring objectives, and 3) a trends evaluation. These pieces are described in broad terms below. The full analyses, including details of the technique, can be found at http://www.epa.gov/ttn/amtic/netamap.html. Although the National assessment was purposefully very general and did not advocate specific network cuts / changes, the approaches utilized may be appropriate for more refined, local assessments of the monitoring networks which can lead to actual network changes.

National Assessment components:

1. Evaluation of measured concentrations as a percentage of the NAAQS: An annual metric, corresponding to each criteria pollutant NAAQS, was computed for every active monitor for years 1998, 1999, and 2000. A 3-year average ('design value') of this metric was then calculated. [Note: Since $PM_{2.5}$ monitoring did not begin in earnest until 1999, a 2-yr 'design value' was used for the 2 $PM_{2.5}$ NAAQS metrics.] The 'design values' were compared to the NAAQS levels and assigned one of 4 bins:

100% or more of NAAQS, 80-100% of NAAQS, 60-80% of NAAQS, and less than 60% of NAAQS. Results were mapped and a National aggregation was bar-charted. Sites in the lower two categories, especially those 'less than 60% of NAAQS' have limited value for NAAQS usage. Although NAAQS usage is one of the central objectives of the criteria networks, other uses and objectives also exist and should be considered. The next described component of the National analyses considers multiple objectives.

2. Multi-objective 'information value' ranking scheme: Five independent measures were chosen to represent the information needs for population exposure, compliance monitoring, and tracking / model evaluation. These measures are: concentration, uncertainty (in 'design value'), deviation from NAAQS, area represented, and population represented. Each monitor was ranked (by pollutant / metric) according to those five measures. The 3-year 'design values' (computed as described above) were used in the calculations of the first three measures. A monitor's location relative to other monitors in the network was used to derive a 'sampling zone' polygon; these polygons were used to compute the latter two measures. Maps were produced for each of the five measures; the monitors in the highest ranked quartile were coded red, the monitors in the middle quartiles were coded black, and the monitors in the bottom quartile were coded blue. Hence, the red monitors were the most important (for that measure) and the blue monitors were the least important. The measure rankings were then aggregated based on several different weighting schemes and composite maps produced (using the same color scheme). Ancillary outputs such as 'Regional Breakdowns of the National Quartiles' and 'Tables of Quartile cutoffs (in measure units)' were also produced.

3. Trends evaluation: A non-parametric 'trend' routine (the same one used in the annual Trends reports) was applied to each monitor's annual metrics in 5- and 10-year cuts ('96-'00 & '91-'00). Each monitor was assigned one of 4 categories: significant upward trend, significant downward trend, no significant trend, or insufficient data. Results were summarized in pie charts. For a case study, the monitor trend information was merged with the output from #2 above and new maps produced showing the trend for specific quartiles (e.g., the blue category) of the aggregate 5-measure ranking. The rationale for this output was, even if a site is 'low value' (blue) in aggregate measure maps, you may want to keep the monitor if it has an upward trend.

Contact: Mark Schmidt (EPA-RTP, OAQPS): (919) 541-2416

## B. Region 3 Approach

The approach to network assessment being proposed by Region III includes both the use of spatial fields and a decision making procedure (Multi-criteria Integrated Resource Assessment MIRA), developed in the Region, that allows for the simultaneous consideration of all relevant and quantifiable criteria. The approach is based upon a premise that tries to define air quality as an estimated spatial field of concentrations with a corresponding estimated field of uncertainties. The geostatistical technique of kriging is used to estimate air quality fields. The scientific merit of a given network design is judged on the certainty with which the actual concentration field can be reproduced from its measured data. The uncertainty field is constructed using modeled benchmark fields of concentrations that present a rational representation of possible future air quality, that is, air quality fields that the designed network is likely to encounter. The MIRA procedure was designed to help make informed and inclusive environmental decisions. It is a modular approach consisting of a Modular Data Collection Manager (DCM) which organizes, warehouses, and prepares data for analysis; a Geostatistical Indicators Module (GIM) that creates environmental indicators (reducing spatial maps to single indexed values for use as indicators); and a Decision Analysis Module which brings data, indicators, judgments together for holistic decision making. The general procedure Region 3 intends to use for network assessment is as follows:

1. Develop an appropriate set of modeled benchmark spatial fields.
2. Construct potential new network designs.
3. Construct a subset of concentrations from the benchmark fields based on the locations of the proposed monitoring sites.
4. Krig the concentration subsets - producing an estimate of the benchmark field.
5. Construct an uncertainty field by comparing the benchmark to the estimated benchmark fields.
6. Establish decision criteria.
7. Quantify the criteria for each network design.
8. Apply the MIRA decision approach.

Additional References:

- *Air Quality Data: A New Conceptual Approach*
  http://www.epa.gov/ttn/amtic/files/ambient/pm25/workshop/spatial/cimorelli.pdf

Contacts: Alice Chow (EPA Region III, AP): (215) 814-2144 [MIRA]
Al Cimorelli (EPA Region III, APD): (215) 814-2189 [spatial fields]
Cynthia Stahl (EPA Region III, APD): (215) 814-2180 [MIRA].

## C. Region 5 Approach:

In response to the ozone and $PM_{2.5}$ networks submitted to the Region by their monitoring agencies, the EPA Region 5 Air Monitoring Section reviewed the networks using a variety of data analysis techniques to determine the importance of monitoring sites. The Region 5 assessments of their ozone and $PM_{2.5}$ networks are capsuled below:

Ozone Assessment in Region 5:

*Summary and Introduction*

Region 5 analyzed the 1996 through 2000 daily 8-hour maximum ozone concentrations measured within the Region as well as surrounding areas to assess the current condition of the individual monitoring sites in relation to each other. The expected outcome of this analysis is a decision between the Region and the State and local air monitoring agencies as to which monitoring locations could possibly be terminated, relocated, or established.[1] To meet this objective, several analyses were conducted. The primary analyses focused on examining how relationships and concentration ratios between monitors are affected spatially between sites. The results of this analysis are intended to complement those obtained through the National Network Assessment.

*Data*

Hourly ozone concentrations were polled from the U.S.EPA Aerometric Information Retrieval System (AIRS) for the years of 1996 through 2000. Only data collected during the primary ozone forming months (May through September) were used for the geographic area of interest. Daily maximum 8-hour averages were calculated as prescribed in 40 CFR Part 50 Appendix H for each of the monitoring sites used in the analysis. All data regardless of flags in AIRS were included.

*Analyses*

Ozone Correlograms

Pearson correlation coefficients (r) were calculated using SAS for every possible monitoring pair combination. A valid correlation coefficient was defined as one where there were at least 75 data points from each of the monitor pairs. Distances between sites were calculated using the following formula:

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[1]Tribal air monitoring activities in the Region 5 area are just beginning to be implemented, and modifications or reductions to their networks are not expected at this time. Tribal agencies will want to use these tools in future assessments after their programs have been developed.

distance = arcos[cos(lat1)*cos(lon1)*cos(lat2)*cos(lon2) + cos(lat1)*sin(lon1)*cos(lat2)* sin(lon2) + sin(lat1)* sin(lat2)]*3963.1925 miles *1.609344 miles/km

where: lat1 and lon1 are the latitude and longitude coordinates of monitor one,
lat2 and lon2 are the latitude and longitude coordinates of monitor two,
1.609344 miles/km is the conversion factor of miles to kilometers.

Plots of the correlation between the two sites and their respective distances were created for every Air Quality Control Region (AQCR) in the Region 5 area of interest. In general, the correlation between two monitors diminishes as the distance between the monitors increases. These plots mainly were used to determine if there were any monitors which were relatively close to each another and had a relatively low correlation between their ozone measurements. This would signify that the monitor pair may be measuring concentrations unique to each site.

Plots of Correlation vs. Ratio between 2 monitors

Ratios of the concentrations between the monitor pairs used in the Correlogram analysis were calculated. Plots of the correlation of the two sites versus the ratio of the two sites were created to help determine if any highly correlated sites had significantly different concentrations.

Plots of Ratio vs. Distance between 2 monitors

Plots were created that display the ratios from the previous analysis versus the distances from the correlogram analysis. This analysis expands on the two previously described procedures to determine sites which are close to each another and may or may not have similar ozone measurements.

Summary Tables

Tables such as the excerpt below summarize the results from the Correlogram, Correlation vs. Ratio, and Ratio vs. Distance analyses.

| Site 1 | Site 2 | Distance (km) | No. Obs. | Corr: R | Avg. Ratio | Median Ratio | Std. Dev. | Min. Ratio | Max. Ratio |
|---|---|---|---|---|---|---|---|---|---|
| 170310001442011 | 170310032442011 | 18.2 | 759 | 0.81 | 0.86 | 0.89 | 0.22 | 0.16 | 2.07 |
| 170310001442011 | 170310037442011 | 34.7 | 92 | 0.83 | 1.14 | 1.12 | 0.33 | 0.21 | 2.67 |
| 170310032442011 | 170310063442011 | 15.4 | 747 | 0.69 | 1.97 | 1.71 | 0.95 | 0.75 | 9.25 |

PMF Results

Positive Matrix Factorization (PMF) was used to determine clusters of monitors displaying similar characteristics based on the concentrations measured at each site. PMF is an analysis technique similar to ordinary factor analysis except that it iteratively solves for both the factor loadings and scores and then predicts an individual monitor concentration. [See ftp://rock.helsinki.fi/pub/misc/pmf/ for details on PMF.] The factor loadings allow for the identification of groups of monitoring locations which exhibit related ozone concentrations. For this, 8-hour daily maximum ozone concentrations were used. Since this analysis requires a complete data record, missing days were estimated using a linear interpolation. Sites which had large amounts of data missing were removed from the analysis entirely.

## $PM_{2.5}$ assessment in Region 5:

### *Summary*

The purpose of this evaluation was to help the Region 5 monitoring agencies to assess the relative value of existing $PM_{2.5}$ monitors. This effort addresses the second basic objective identified in the *Regional Strategy* - identification of divestment opportunities. Parallel efforts by Region 5 and their monitoring agencies will identify areas for potential addition of $PM_{2.5}$ and other criteria pollutant monitors and will also promote expansion of the *State and Local Agency Regional Air Toxics Monitoring Network.*

### *Analyses*

The Region 5 $PM_{2.5}$ monitors were evaluated on the basis of four decision criteria: 1) mean concentration, 2) monitor density, 3) correlation, and 4) population change. These criteria were designed to provide insight into the relative value of monitoring sites on the regional scale. The four criteria are described below and general findings are presented. This section is followed by suggestions on how to apply these findings.

#### Mean Concentration

A mean concentration and standard deviation were calculated for each monitor for the period of January 1999 - March 2001. Results were compiled in a spreadsheet and also mapped. Sites with fewer than 60 measurements were not evaluated (coded 'NA' on the spreadsheet). Sites were color-coded on maps and spreadsheets to indicate their relative value in terms of $PM_{2.5}$ concentration. Region 5 monitoring sites were divided into five equally sized groups (quintiles) and color-coded as follows:

| | |
|---|---|
| blue | 6.86 - 12.21 $\mu g/m^3$ (lowest value sites) |
| light blue | 12.24 - 14.04 $\mu g/m^3$ |
| pink | 14.05 - 15.33 $\mu g/m^3$ |
| red | 15.34 - 17.32 $\mu g/m^3$ |
| dark red | 17.34 - 20.82 $\mu g/m^3$ (highest value sites) |

Please note that the same quintile color coding was used throughout the entire analyses. Monitors measuring lower $PM_{2.5}$ concentrations (with respect to the quintile ranges) are deemed less valuable than those giving higher measurements.

Site Density

Distance was measured from each individual monitor to the next nearest site, not including co-located monitors. Monitors in adjoining Regions were also considered as potential closest sites. Sites are color-coded on maps and spreadsheets to indicate their relative value in terms of site density. Monitors located closest to another site are deemed less valuable than those more isolated from other sites. Sites were divided into quintiles with blue sites having the lowest values (distance to nearest $PM_{2.5}$ site) and dark red sites having the furthest distances.

Monitor Correlation

Pearson correlation coefficients (R) were determined for each pair of monitors in Region 5 and adjoining states. The single highest correlation coefficient (R) for each monitor was identified. Results were compiled in a spreadsheet and also mapped. Sites with fewer than 60 measurements were not evaluated (coded 'NA' on the spreadsheet). Sites were color-coded on maps and spreadsheets to indicate their relative value in terms of monitor correlation. Monitors most highly correlated to another site are deemed less valuable than those with lower correlations. Dark red sites have the lowest R values and blue sites have the lowest R values.

Population Change

Percent population change (between 1990-1999) was indicated for the county in which each monitor is located. Data were obtained from the U.S. Census Bureau.

*Application of Network Assessment Results*

The above described decision criteria are not intended to be used independently, that is, we should not simply eliminate all low-reading monitors or cut the most highly correlated monitors in the Region. Rather these criteria should be considered together and incorporated with other factors specific to each State and local agency. Despite the fact that the four decision criteria are quantitative in nature, it is difficult to quantitatively evaluate a group of monitors considering all four criteria simultaneously. The network reviewer may either: a) look at all decision criteria simultaneously in a qualitative way, or b) look at the criteria quantitatively in a stepwise manner as described below.

The following steps may be followed to identify the best candidates for elimination from a network. The network evaluator must first prioritize the importance of the described decision criteria. The suggested steps assume the following prioritization in decision making (criteria listed in decreasing order of importance): a) density, b) correlation, c) mean, d) population change.

1. Locate the information pertaining to the metropolitan area or State of interest on the results spreadsheet. Copy the pertinent rows into a blank spreadsheet.
2. Sort the rows based on Site Density.
3. Narrow the list by deleting the 50% of sites with the highest monitor value for Site Density, i.e., monitors which have a farther distance to the next monitor
4. Sort the remaining rows based on Correlation
5. Further narrow the list by deleting the 50% of sites with the lowest value for Correlation, i.e., monitors with lower correlations
6. From these remaining sites (the most redundant 25%), consider those with lower concentration means and lower population growth as the first candidates for network elimination.
7. Incorporate local issues and priorities in making final decisions

An alternate prioritization of the four criteria is possible, for example correlation may be considered the most important factor to consider, rather than site density. Further, the network reviewer may narrow the list to a different extent (more or less than a 50% cut in steps 3 and 5) depending on the size of the current network, the number of desired deletions, or other considerations. It is up to the monitoring agencies to decide how to best apply these results. According to the described assumptions, the sites remaining in the table may be considered the leading candidates for elimination in the Region. A portion of the table from the Region 5 analysis is shown below.

| AIRS ID | Mean (µg/m$^3$) | Distance to Next Site | Correlation, Highest (R) | County Population Growth, Percent |
|---|---|---|---|---|
| 1716100031 | 14.84 | 6.4 | 0.966 | -15 to 0% |
| 5507900592 | 14.54 | 6.9 | 0.971 | -15 to 0% |
| 5507900991 | 14.45 | 2.0 | 0.978 | -15 to 0% |

Agencies may wish to follow this same process on a statewide or citywide level to determine relative value of monitors on their localized scale. If multiple sites from the same area are left in the table, the reviewer should not assume that all should be eliminated! Rather, the State should select among these sites, with the prime candidates identified as the monitors with a combination of lowest mean, highest density, and highest correlations. States may need to cycle through the entire process (including recomputation of the 4 metrics) after 'eliminating' a single or small number of monitors since the metrics and relative site values may change.

Contacts: Motria Poshyvanyk (EPA Region V, ARD): (312) 886-0267 [$PM_{2.5}$]
Mike Rizzo (EPA Region V, ARD): (312) 353-6324 [ozone]

## D. Region 8 Approach

D.1 Introduction

The EPA Region 8 monitoring staff, in partnership with the Region 8 state and tribal monitoring organizations, is currently engaged in an assessment of the ambient air monitoring network within the region. This assessment is in response to national assessment and requests from OAQPS.

The overarching goal of the regional assessment is to identify opportunities to increase efficiency and reduce redundancy within the existing network, in order to increase the resources available for new monitoring initiatives. From the National Monitoring Strategy, these new initiatives include increased deployment of continuous monitoring methods with real-time reporting to the public (primarily via the internet), increase air toxics monitoring, and new multi-pollutant urban sites. Given the top level goal, specific objectives of the 2002 regional assessment as formulated by the regional staff are:

- Build partnerships with State/Tribal Agencies for a network assessment and improved design;
- Conduct quantitative and qualitative Regional analyses of monitor values;
- Report Regional response to strategy and assessment results to OAQPS.

### D.1.1 National Monitoring Strategy

In part, the regional network assessment is in response to the efforts at EPA to define a National Monitoring Strategy for the first decades of the 21$^{st}$ century. The strategy has been in development for more than 2 years, and continues. The strategy seeks to find ways to transition from earlier monitoring priorities to current priorities, such as increased continuous monitoring and reporting, and increased monitoring of airborne toxics. In the 1990s, increasing numbers of areas in the United States made great strides in improving their CO, $PM_{10}$ and $O_3$ air quality, suggesting that networks designed for the high pollution years of the 1970s and 1980s may now have excess capacity in these and other criteria pollutants. The National Monitoring Strategy seeks to use good science methods to identify low benefit monitors nationwide which can be replaced by new monitors using new methods and addressing new criteria and other pollutants (continuous $PM_{2.5}$, PMcoarse, PM speciation, Toxics, etc.) More information on the monitoring strategy development is available at http://www.epa.gov/ttn/amtic/monitor.html.

### D.1.2 Region 8 Background

EPA Region 8, consisting of the states of Utah, Colorado, Wyoming, Montana, North Dakota and South Dakota comprises a large, mostly rural section of the interior of the United States. The continental divide bisects the region from north to south, and the topography ranges from the Great

Basin valleys of western Utah to the Great Plains of Montana, Colorado and the Dakotas. Region 8 is second only to Region 10 (with Alaska) in land area and lowest population density. Corner to corner, the region is more than 1100 miles in length (St. George, Utah to Grand Forks, North Dakota), equivalent to the distance from Durham, NC to Dallas, TX, or from Washington, D.C. to Sioux Falls, South Dakota.

Indicative of large, rural areas, three of the states in Region 8 are termed "half-percent" states. The populations of these states (Wyoming, North Dakota and South Dakota) are each less than 0.3% of the national total, and the states receive 0.5% of the national ambient air management grant funds in accordance with section 105 of the Clean Air Act. These states lack large population centers (the Fargo, North Dakota - Moorehead, Minnesota MSA, at 174,367 and Sioux Falls, South Dakota MSA, at 172,412 are the largest cities in these three states). The three states combined have one non-attainment area: Sheridan, Wyoming is non-attainment for $PM_{10}$ (last exceedance in 1997).

The region does contain two large metropolitan areas: the Denver – Boulder – Greeley CMSA, the 19$^{th}$ largest in the country in 2000, with 2.58 million people, and the Salt Lake City – Ogden MSA, number 36 in the country, at 1.33 million people. With the exception of $PM_{10}$ and $SO_2$, between 30 and 60 % of the region's monitoring assets are concentrated in these two urban areas, depending on parameter.

For the parameters $PM_{10}$ and $SO_2$, large numbers of industrial monitors exist in the region. These monitors are not funded with EPA grant monies, and long term continuity cannot be assured through EPA oversight. Taking into account the nature and potential transience of these industrial monitors constitute one of the largest differences between the Region 8 network assessment, and the National Assessment.

### D.2 Region 8 Network Assessment Approach

The National Assessment of air pollution monitoring networks was a purely quantitative approach. The assessment calculated 5 parameters which could be used to rank monitors in terms of relative importance. These 5 parameters were:

- Pollutant Concentration – does the site measure high concentrations, relative to the NAAQS, and hence record high health impacts?
- Estimation Uncertainty – how uncertain are a station's measurements, given knowledge of adjacent stations?
- Deviation from NAAQS – are peak measured pollutant levels far above or below the NAAQS, on near the NAAQS?
- Spatial Coverage – a ranking on monitoring sites based on land area represented. This is a purely geometric consideration based on map area of polygons drawn around monitors.
- Persons/Station – a ranking based on the populations included in the surrounding

representative polygon.

Once calculated, the parameters could be combined using various weightings to arrive at quantitative comparisons of the relative worth of monitors.

In using a single, purely quantitative approach, several other relevant quantitative and qualitative parameters were necessarily neglected. For instance, the represented area used does not take into account topographic barriers to air flow (mountain ridges, for example), and may have assumed monitors were representative of areas from which they are in fact physically isolated. Also, the data set used in the National Assessment consisted of all EPA reference method monitors included in AIRS. This include NAMS, SLAMS, tribal, and special purpose monitors under the oversight of EPA, as well as reference method monitors operated by other government and private organizations. In selecting an optimized network design, EPA Region 8 feels it is important to restrict the assessment to monitors over which EPA has oversight and some level of control; otherwise, a conclusion about a particular monitor's worth may be reached based on the proximity of other monitors whose persistence and schedule are subject to change. In the worst case, a SLAMS or other governmental monitor might be concluded to be of little value because of the presence of an industrial monitor, which subsequently could be deactivated at any time as industrial operations change.

EPA Region 8 will conduct an assessment of monitors in the region intended to augment the National Assessment. Analyses will be conducted in three separate areas:

1. Regulatory and budgetary analysis
2. Topographic/meteorological analysis
3. Statistical correlation analysis.

### D.2.1 Regulatory and Budgetary Analysis

#### D.2.1.1 Regulatory Context of the Monitoring Network

In response to the National Monitoring Strategy, a regulatory workgroup, with EPA, State and Local participation, is looking at proposed changes to the Code of Federal Regulations to bring the monitoring network requirements into line with the current national needs. In the meantime, the CFR contains requirements for SLAMS and NAMS networks which must be met until regulation changes are approved. The Region 8 regulatory and budgetary analysis will address the portion of the ambient air monitoring network currently required by the CFR. To the extent that the nature of eventual changes to the CFR can be anticipated, the analysis will address possible changes to the network that could be implemented after the CFR is revised.

#### D.2.1.2 Grant Context of the Monitoring Network

From a funding standpoint, the current Performance Partnership Agreement framework allows for a great deal of flexibility, allowing states to determine how best to use monitoring funds to protect the health of their citizens. Separation of the monitoring monies into Section 105 and Section 103 grants, on the other hand, limits the flexibility for a part of the monies, in that Section 103 monies currently are to be used primarily for $PM_{2.5}$ and air toxics monitoring. The National Assessment has taken an idealized approach to generate theoretical optimization schemes without consideration of funding. The budgetary analysis portion of the regional assessment will discuss the current grant structure in more detail, particularly to examine how the grant structure may make implementation of regional or national network assessment recommendations more difficult.

### D.2.1.3 Funding of Monitors

The National Assessment utilized all monitoring data in the AIRS database to assess the relative worth of monitors across the nation. In Region 8, more so than in some other EPA regions, many monitors in AIRS are operated by government and private organizations for purposes other than assessing compliance with the NAAQS and protecting human health. For some states, the monitoring networks operated by industry to monitor industrial emissions are far larger than the networks operated by the state and local governments for NAAQS compliance. Monitoring networks operated without (or with minimal) EPA funding and oversight will be assessed to attempt to determine how the National Assessment might have been different without these industrial and non-EPA monitors, with the objective of ensuring the network needed for ambient air NAAQS compliance and public health protection remains robust.

### D.2.1.4 Network Assessments and Annual Network Reviews

The states of Region 8 currently conduct annual network reviews as required under the CFR. Region 8 has previously developed guidelines on the content and process of the reviews, and the products of the Region 8 states are generally very well prepared and thorough. Requirements to conduct network assessments on some schedule less frequent than annually are being considered for inclusion in the CFR. The differences between the annual network reviews and the less frequent network assessments are yet to be defined, but the network assessments may be required to use statistical methods to quantify the relative values of monitoring sites, as well as look at monitor coverage across state and regional boundaries. For the current first round Network Assessment in Region 8, the EPA will be conducting statistical analyses of monitors. EPA is asking the states in the region to participate by considering the state of their monitoring networks relative to the current state of their air quality (i.e., consider how their networks might change after redesignations to attainment or considering long term data trends), and how the state networks might be adapted for a greater emphasis on real time pollution reporting and mapping, monitoring of air toxics, and real time particle speciation monitoring. Any comments the states may have on the National Monitoring Strategy or the National Assessment should also be forwarded to the Region 8 office with the Network Review.

### D.2.2 Topographic and Meteorological Analysis

The national assessment considered the area covered by a monitor, represented by the area of a polygons containing points closer to a given monitor than to any other. For mountainous areas, topography can effectively isolate airsheds, and a purely geometric consideration can lead to improper representative area assumptions. Also, in Region 8, long range transport of pollutants is not commonly a problem. High pollution levels tend to be seen near sources (urban or industrial areas) or at a characteristic location relative to sources for secondary pollutants. Proper network design in Region 8 can include high monitor densities near the large urban centers (Salt Lake City and Denver), with sparse rural coverage representing very large areas, in order to detect concentration gradients and peak concentration locations. Additionally, local topography can serve to channel pollutants toward particular areas, justifying monitor clusters that pure geometric coverage considerations would devalue. The topographic and meteorological assessment of the regional network will consider such localized issues, and complement the quantitative assessment below.

### D.2.3 Statistical Evaluation

Pairwise correlation will be used as the primary tool for assessing redundancy in the regional network. SAS will be used as the primary statistical tool, because the numbers of monitor pairs in the region can exceed the capabilities of typical spreadsheets. Where appropriate, such as in the four corners region and in northwest Montana, monitors in adjacent EPA regions will be considered if they are close enough to potentially overlap monitors in Region 8. As data for the fourth quarter of 2001 may not appear in the reengineered AIRS database in a timely manner (due March 31, 2002, but the new AIRS only came on line at the end of January), the three years of data from 1998 to 2000 will be the primary data set considered. Correlations of both complete data sets, and subsets of data consisting of high pollution days for at least one monitor in the set will be conducted to see that high correlations of low values don't mask pollution event statistics.

## D.3 Region 8 Network Assessment Report

A report of the Region 8 Network assessment will be generated in the summer of 2002. The report will include the results of the regional analyses, as well as regional (state, tribal and EPA) comments on the National Assessment and National Monitoring Strategy.

## D.4 Schedule

The following milestones have been established for the Region 8 Network Assessment:

| | |
|---|---|
| Brief Region 8 State Air Directors on Regional Assessment | Feb. 13, 2002 |
| Prepare Draft Text of Topographical/Meteorological Assessment | April 30, 2002 |
| Receive State Inputs | June 1, 2002 |
| Prepare Draft Text of Regulatory/Budgetary Assessment | June 28, 2002 |

| | |
|---|---|
| Prepare Final Report Draft for Internal Review | Aug. 30, 2002 |
| Submit Final Report to OAQPS | Sept. 20, 2002 |

## E. Design Interface Tool

The Design Interface (DI) is a software package that provides a graphical interface to evaluate alternative networks. The Design Interface makes extensive use of S-Plus which is a software package widely used by statisticians and data analysts. The existing version of DI allows users to input an arbitrary network of ambient monitors along with mathematical formulas used to describe the spatial structure of the data. From this information, the user is able to delete or add monitoring stations and display the consequences in terms of spatial predictions and uncertainties. For example, users can estimate the probability that an unmonitored area is exceeding a harmful threshold given concentration data from the network of nearby monitoring stations. Software and documentation for the current version of DI is available at the following web site: http://www.cgd.ucar.edu/stats/DI/.

EPA is upgrading DI to improve the data interface to DI so that data from AIRS and other sources can be easily inputted into the system. In addition, DI is being modified to include technical improvements and flexibility for the user in selecting network performance measures needed to evaluate alternative monitoring network designs. A feature will be added to enable users to examine and validate statistical assumptions about the spatial covariance structure and permit simple graphical display of correlation among monitors using brushing and highlighting techniques. Documentation will be significantly improved and example problems expanded to include ozone and $PM_{2.5}$ for a hypothetical planning area. Since DI is structured around the S-Plus language, users of DI must have access to S-Plus and the S-Plus spatial module. The enhanced version of DI should be available for user testing by late spring 2002.

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**F. Additional Techniques Under Development**

The elements listed below came to fruition based on discussions at the Spatial Data Analysis Technical Exchange Workshop held December 3-5, 2001 in the Research Triangle Park, NC. [Presentation materials from that workshop can be found at http://www.epa.gov/ttn/amtic/spatlwrks.html.] The activities listed below will be pursued in parallel with each of the ongoing monitoring network assessments. The purpose of these elements is to establish a framework for generating reliable spatial fields. The statistical theory that is used to develop space-time models of ambient concentrations is evolving. As techniques and tools are developed, these will be made available for use in understanding airsheds, designing monitoring networks, developing control strategies, and supporting epidemiological studies.

One element is a white paper, proposed to be completed in April 2002. At the workshop, several people suggested that the participating scientists prepare a white paper describing the benefits of using interpolated spatial fields instead of using only points in space. There are several statistical papers addressing this approach. Summaries of these papers together with a discussion about the potential policy uses of spatial fields will comprise the white paper. The workshop participants agreed that this white paper could be a catalyst for getting spatial fields into the regulatory process.

The second element is a round robin by collaborators and EPA scientists to compare and contrast various techniques for developing fields of spatial predictions and associated uncertainties. Three to five emerging techniques as well as some of the techniques described in this Guidance will be part of the round robin, and each technique will be applied to the same database. The basics of the round robin include a series of objectives that get progressively harder. What is learned from each stage will hopefully be incorporated into existing tools, such as the previously mentioned Design Interface tool, so that agencies can use the tools for improved spatial prediction and network design. The series of objectives include:

1. Prediction of field of $PM_{2.5}$ 3-year average of annual average concentrations and uncertainties.
2. Prediction of field of $PM_{2.5}$ 3-year average of $98^{th}$ percentiles and uncertainties.
3. Forecasting of field of daily $PM_{2.5}$ concentrations in support of public reporting.
4. Prediction of 3-year average of $4^{th}$ max 8-hour average ozone concentration.
5. Multi-pollutant prediction.
6. Optimal designs.

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## III. Acronyms & Web Sites

AIRS - U.S. EPA's Aerometric Information Retrieval System (reference web site: http://www.epa.gov/airsdata.

AQCR - Air quality control region (reference 40 CFR 81)

CASTNet - Clean Air Status and Trends Network (reference web site: http://www.epa.gov/castnet)

CFR - Code of Federal Regulations

DCM - Data collection manager

DI - Design interface tool (reference web site: http://www.cgd.ucar.edu/stats/DI/)

GIM - Geostatistical indicators module

IMPROVE - Interagency Monitoring of Protected Visual Environments (reference web site: http://vista.cira.colostate.edu/improve)

MIRA - Multi-criteria integrated resource assessment, developed by EPA Region 3.

NAAQS - National Ambient Air Quality Standards (reference 40 CFR 50)

NADP - National Atmospheric Deposition Program (reference web site: http://nadp.sws.uiuc.edu)

NMSC - National Monitoring Strategy Committee (reference web site: http://www.epa.gov/ttn/amtic)

OAQPS - Office of Air Quality Planning and Standards, U.S. EPA

PMF - Positive matrix factorization (reference web site: ftp://rock.helsinki.fi/pub/misc/pmf/)

QA - Quality assurance

RTP - Research Triangle Park, North Carolina

SLAMS - State and local air monitoring stations (reference 40 CFR 58)