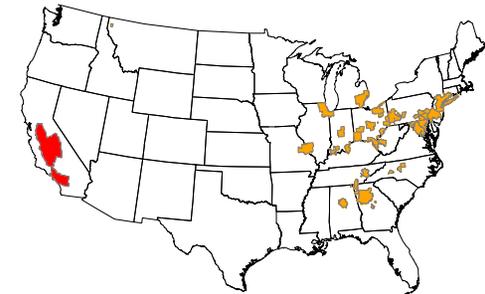


Air Monitoring Regulations - Focus on Fine Particles

Mark Schmidt
EPA – OAQPS
Air Quality Data Analysis Group



Tim Hanley
EPA – OAQPS
Ambient Air Monitoring Group



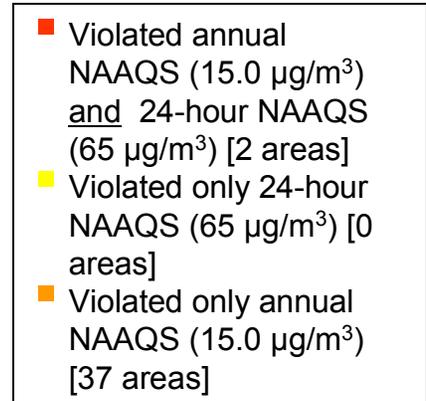
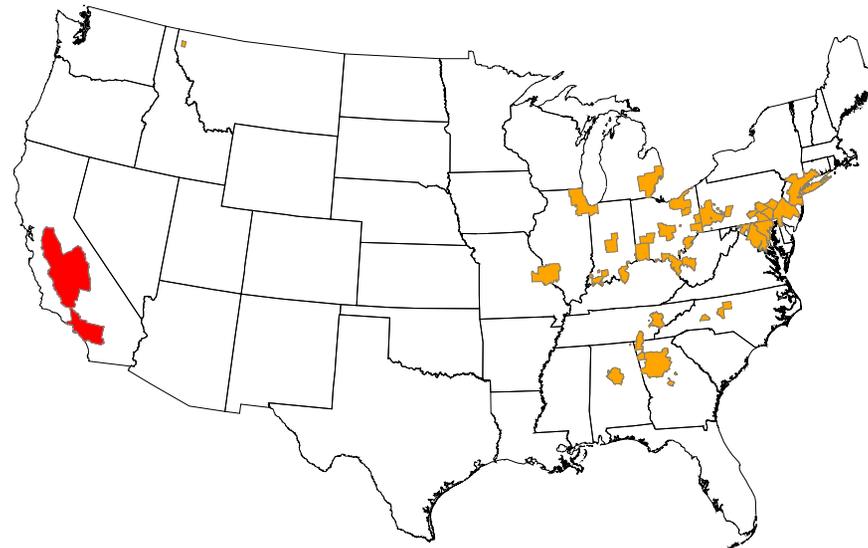
National Air Monitoring Conference
Tuesday November 7, 2006

Focus on Fine Particles – Data Analysis Issues

- 1997 NAAQS Status
- 2006 NAAQS Changes:
 - Ramifications of tightened 24-hour standard
 - 98th percentile bias associated with sampling frequency
 - Spatial averaging implications

PM_{2.5} - 1997 NAAQS Status

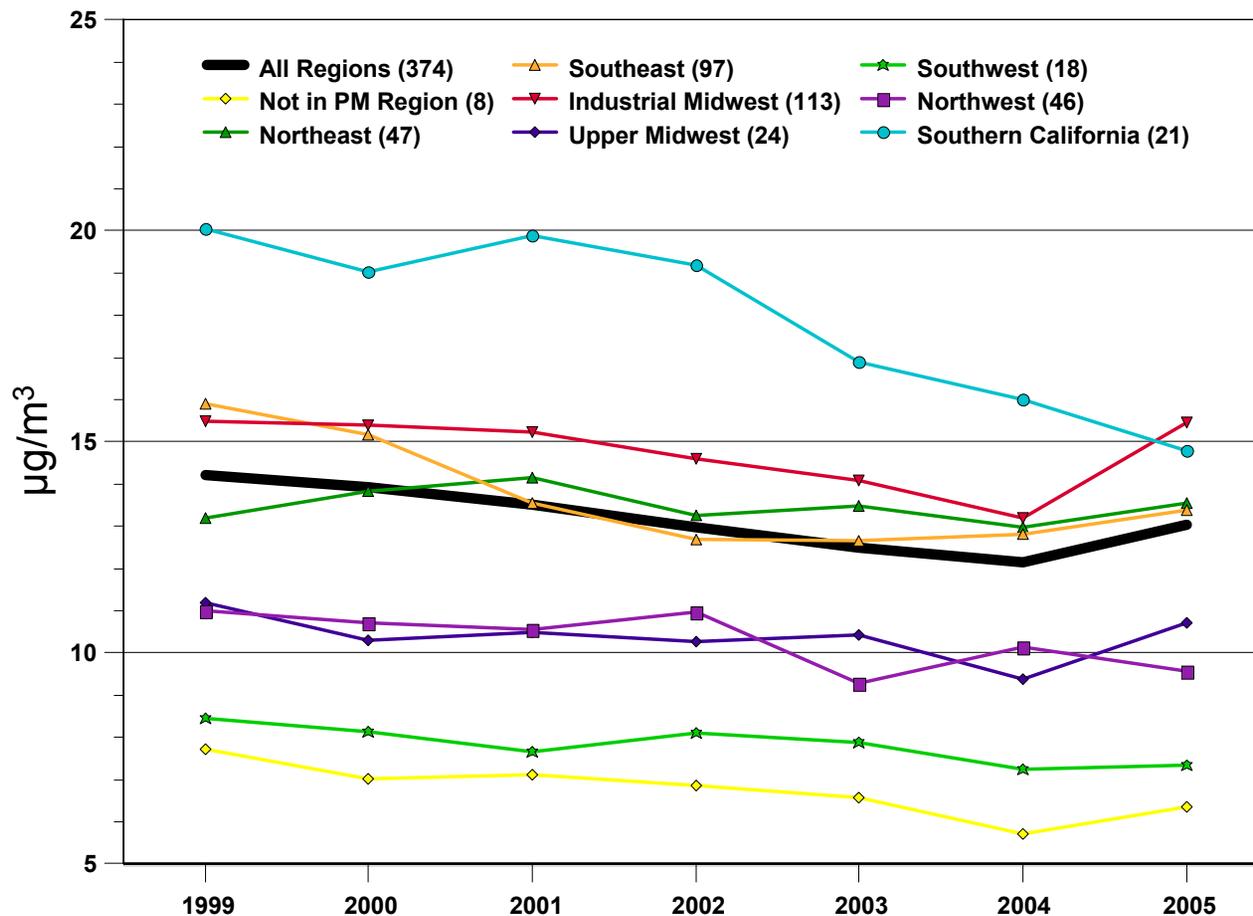
Designated PM_{2.5} Nonattainment Areas



- Final area designations made April, 2005
 - 39 areas designated ‘nonattainment’; 1 area designated ‘unclassifiable’.
 - Designations based on 2001-2003 data.

PM_{2.5} - 1997 NAAQS Status

Annual Mean Trend, 1999 - 2005

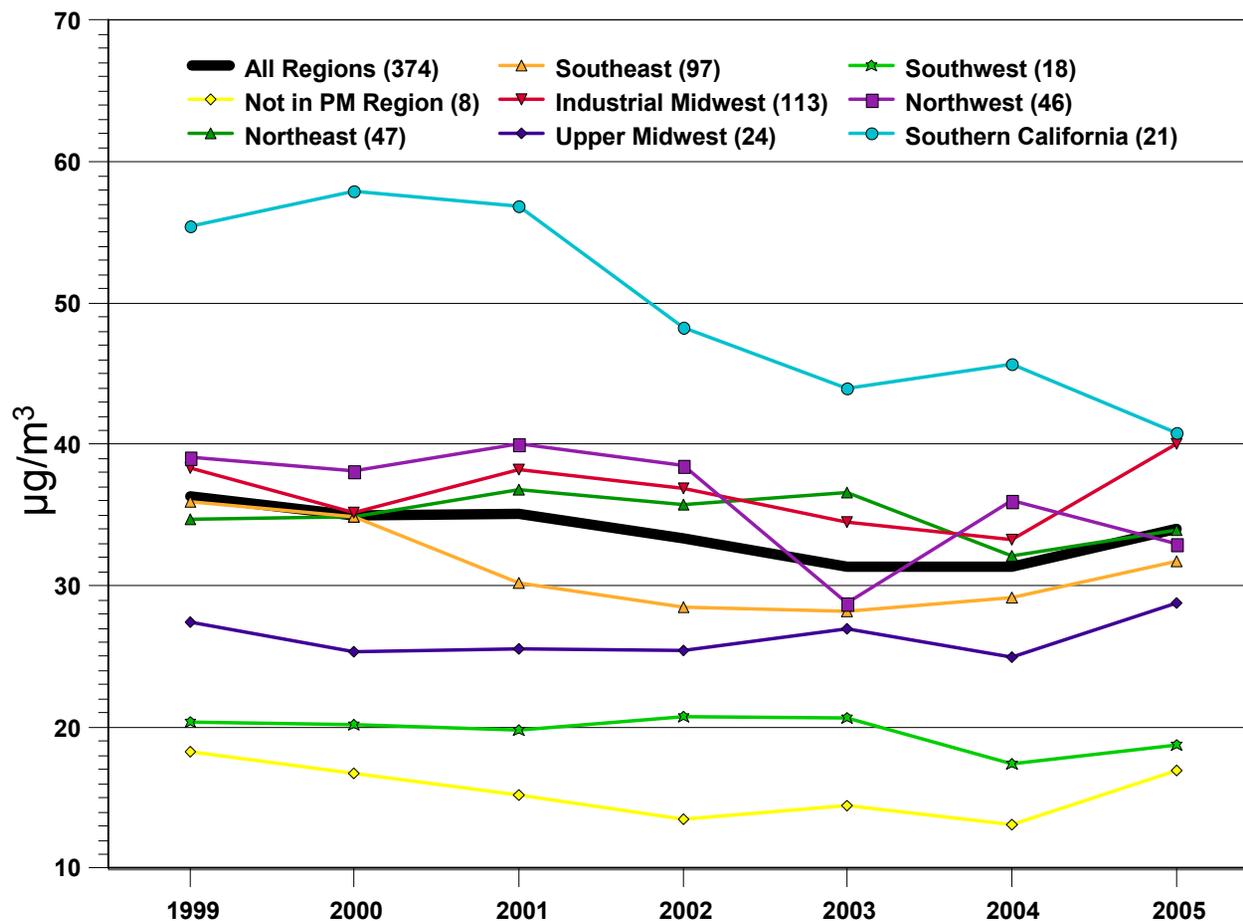


There have been overall declines in average PM_{2.5} levels

- National decline of 8% from 1999 to 2005 ...
 - 15% reduction '99 to '04
 - 7% increase '04 to '05
- Largest reductions in Southern California where levels are highest (-26%)
- Increases in Upper Midwest (+5% '99 to '05) and Industrial Midwest (+4% '99 to '05)
- Declines partially attributed to Acid Rain program (SO₂ reductions)
- 2005 increases due in part to sulfate increases & meteorology

PM_{2.5} - 1997 NAAQS Status

98th Percentile Trend, 1999 - 2005



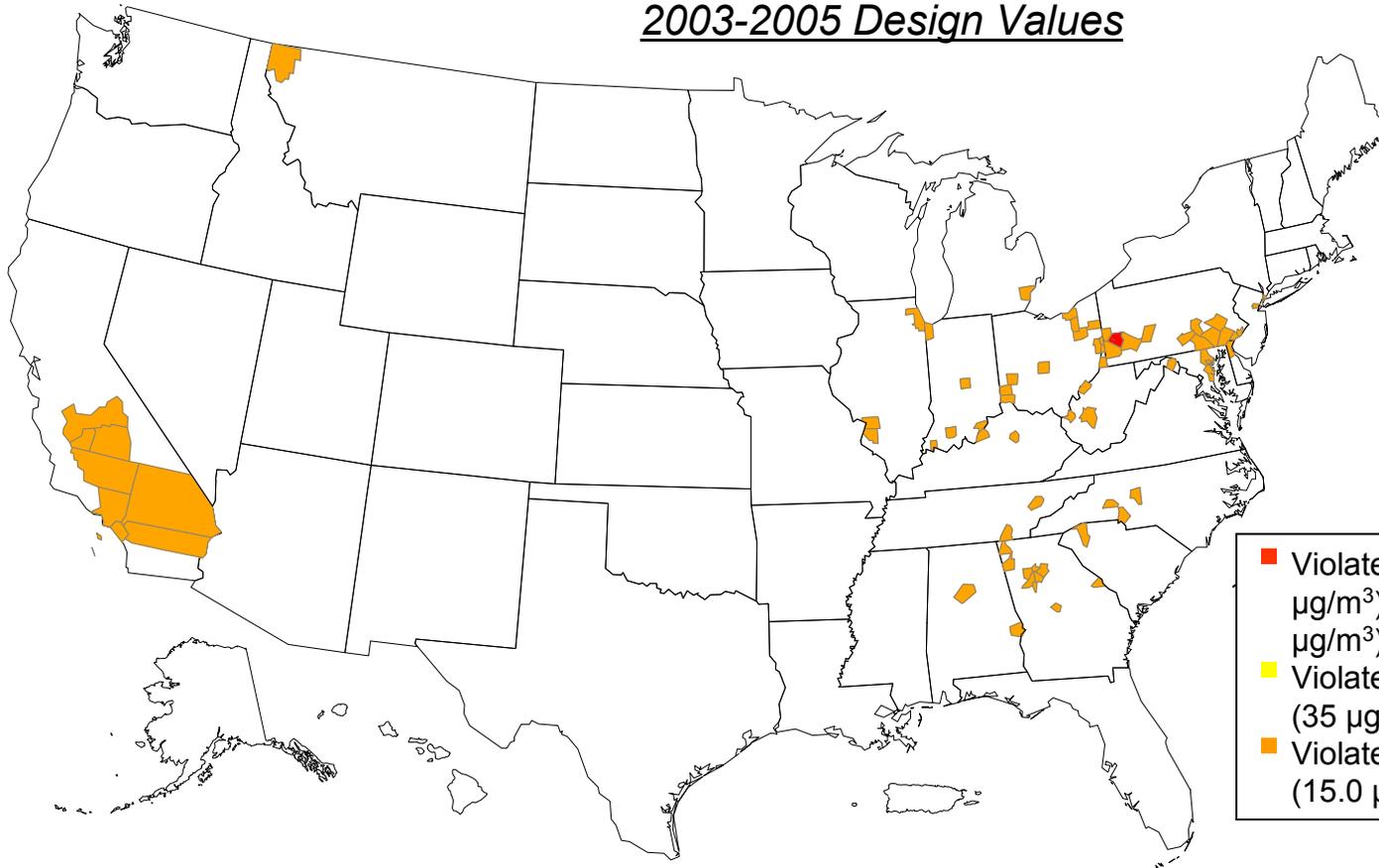
There have been overall declines in average PM_{2.5} levels

- National decline of 6% from 1999 to 2005 ...
 - 14% reduction '99 to '03
 - no change '03 to '04
 - 9% increase '04 to '05
- Largest reductions in Southern California where levels are highest (-26%)
- Large increases in Industrial Midwest. Also Upper MW & NE ('99 to '03)
- 2005 increases due in part to sulfate & meteorology

$PM_{2.5}$ – 1997 NAAQS Status

Current picture – 15 / 65

2003-2005 Design Values

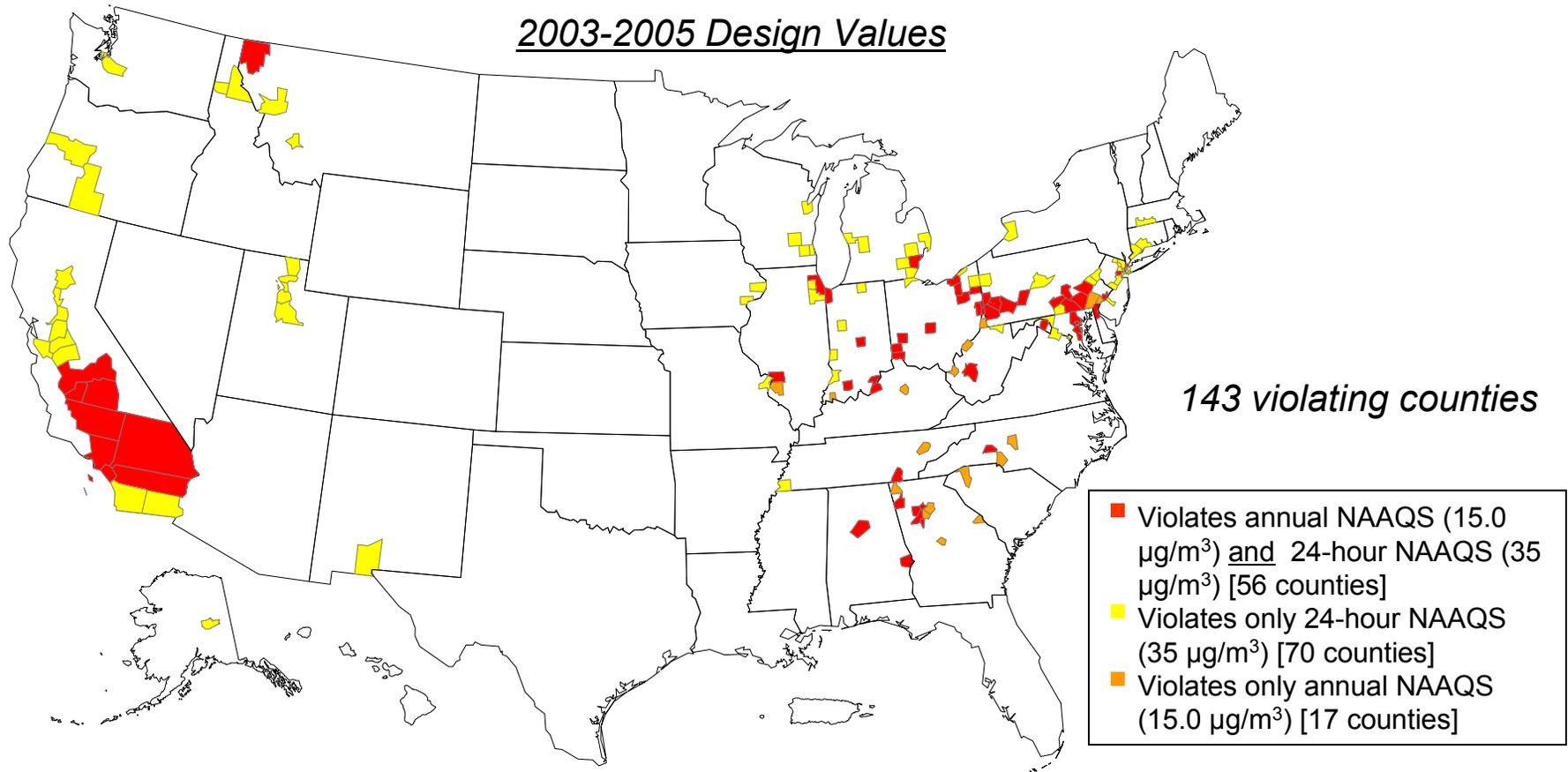


- 73 violating counties
- All but 6 are located in nonattainment areas: Greenville, SC; Russell, AL (Columbus); Richmond, GA (Augusta); Fayette, KY (Lexington); Mecklenburg, NC (Charlotte); Mahoning, OH (Youngstown)
- All counties in D.C. NAA are clean

- Violates annual NAAQS ($15.0 \mu\text{g}/\text{m}^3$) and 24-hour NAAQS ($65 \mu\text{g}/\text{m}^3$) [1 county]
- Violates only 24-hour NAAQS ($35 \mu\text{g}/\text{m}^3$) [0 counties]
- Violates only annual NAAQS ($15.0 \mu\text{g}/\text{m}^3$) [72 counties]

PM_{2.5} - 2006 NAAQS Changes

Ramifications of tightened 24-hr std (15 / 35)



PM_{2.5} - 2006 NAAQS Changes

Ramifications of tightened 24-hr std (15 / 35)

Expected Timeline for PM_{2.5} NAAQS Implementation

Dec. 2006	Effective date for revised 2006 PM _{2.5} NAAQS
Dec. 2007	States recommend designations for revised PM _{2.5} 24-hour standard. Using '04-'06 or '05-'07
Dec. 2009	Final designations for revised PM _{2.5} 24-hr std
April 2010	Effective date for revised PM _{2.5} 24-hr std area designations
April 2013	State plans due for revised PM _{2.5} 24-hr std.
April 2015-2020	Attainment date for revised PM _{2.5} 24-hr std

PM_{2.5} - 2006 NAAQS Changes

98th Percentile Bias

- There is a potential for bias in EPA's prescribed method of 'calculating' 98th percentile values.
- **The EPA method tends to underestimate 98th percentile values.** (By an average of about 0.8 µg/m³)
- The bias is associated with sampling frequency; **the potential for bias is greater with less frequent sampling schedules** (i.e., 1/6 > 1/3 > 1/1).
- The EPA method (per Appendix N) identifies an actual sample value (i.e., a discrete value) as the 98th percentile; interpolation / estimation is not utilized

PM_{2.5} - 2006 NAAQS Changes

98th Percentile Bias

EPA method of assigning annual 98th percentile

- The EPA method (per Appendix N) identifies an actual sample value (i.e., a discrete value) as the 98th percentile; interpolation / estimation is not utilized

<u>Number of creditable samples</u>	<u>Assigned 98th percentile is nth max</u>
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

PM_{2.5} - 2006 NAAQS Changes

98th Percentile Bias

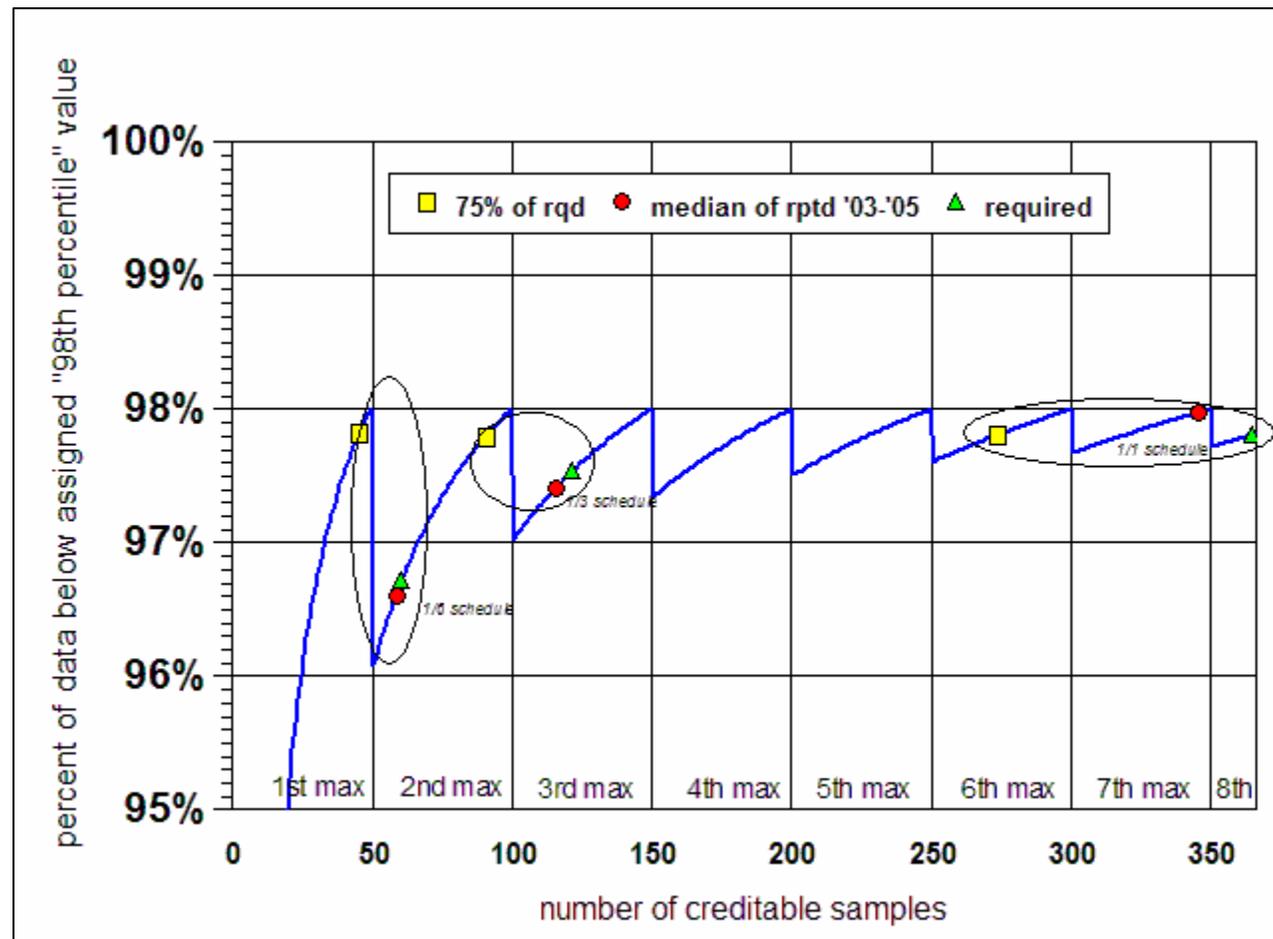
- With the EPA method (for ‘calculating’ 98th percentiles), a site that samples correctly will never have an annual 98th percentile value below which fall more than 98% of the year’s data. Usually, less than 98% of the data will fall below the assigned 98th percentile value. Exactly 98% of data will fall below the assigned 98th percentile value only when the number of observations is a multiple of 50 (e.g., 50, 100, ..., 350).
- The further you are from the next multiple of 50, the greater this potential bias.

PM_{2.5} - 2006 NAAQS Changes

98th Percentile Bias

Example: 1/6 schedule

- 100% data capture (~61 samples)
 - Use 2nd max
 - 96.7% of obs fall below.
- 75% data capture (~46 samples)
 - Use 1st max
 - 97.8% of obs fall below
- Worst-case (meeting 75%+) = 51 samples
 - Use 2nd max
 - 96.1% of obs fall below

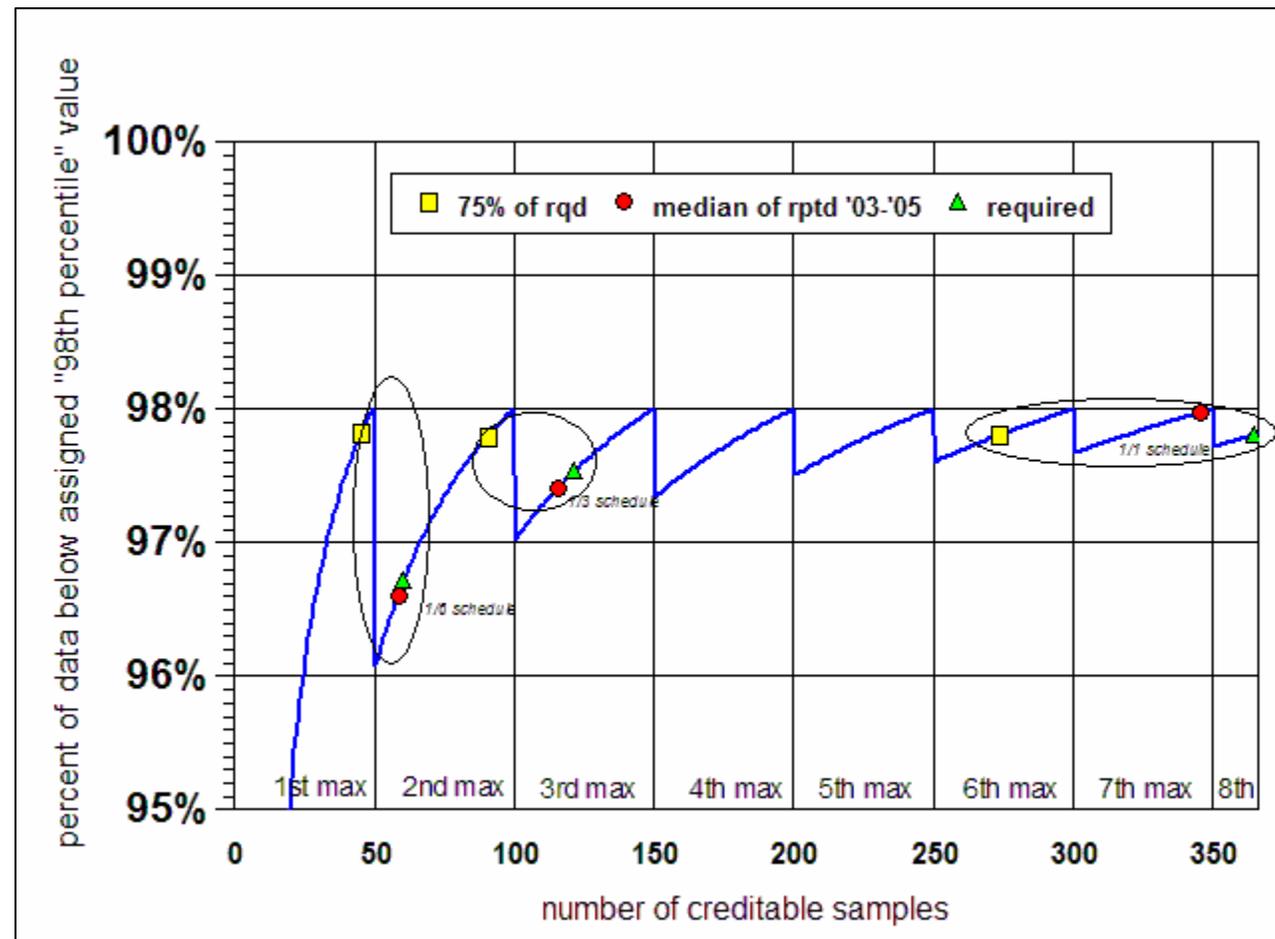


PM_{2.5} - 2006 NAAQS Changes

98th Percentile Bias

Example: 1/1 schedule

- 100% data capture (~365 samples)
 - Use 8th max
 - 97.8% of obs fall below.
- 75% data capture (~274 samples)
 - Use 6th max
 - 97.8% of obs fall below
- Worst-case (meeting 75%+) = 301 samples
 - Use 7th max
 - 97.7% of obs fall below



$PM_{2.5}$ - 2006 NAAQS Changes

98th Percentile Bias

How to address

- We could have changed calculation protocol (i.e., estimate)
 - But, there are numerous available ‘estimation’ methods
 - And, we didn’t ‘propose’
- We opted to require every day sampling (1/1) for *key sites close to the NAAQS*
 - A ‘key’ site is the highest one in a metro area; ‘close’ is within 5% (both based on 3-yr DV)
 - This will also help reduce sampling bias (caused by unrepresentative sample days)
 - About 50-60 sites will need to start sampling daily in 2007. (Refined list considering NAA coming next week. Seasonal sampling may be OK. List to be negotiated - OAQPS/Regions/States)

PM_{2.5} - 2006 NAAQS Changes

Spatial Averaging

- In the NAAQS review, EPA seriously considered eliminating the spatial averaging (SA) option.
 - There are ‘environmental justice’ concerns with SA
 - **In general**, the highest sites (in an MSA) are typically located in areas of lower income, higher percentage minority, and/or lower education levels compared to other locations (in the MSA)
- If SA was to be kept (which it was), the criteria had to be tightened based on our new knowledge of the data.

PM_{2.5} - 2006 NAAQS Changes

Spatial Averaging

1997 Criteria

1. Minimum of 0.6 overall correlation among sites
2. No more than 20% difference in any site annual mean versus the spatial annual mean.
3. All SA sites should be affected by the same emission sources.

PM_{2.5} - 2006 NAAQS Changes

Spatial Averaging

1997 Criteria

1. Minimum of 0.6 overall correlation among sites

But, we found ...

- In an analyses of all site pairs in metro areas (2000+ pairs), 95% of those pairs had an overall correlation greater than 0.7, and the median correlation was 0.9
- There was some significant differences between the annual correlation and the minimum seasonal correlation. (Avg. diff = 13%. More than 25% of the pairs had a difference of > .11 R)

PM_{2.5} - 2006 NAAQS Changes

Spatial Averaging

1997 Criteria

2. No more than 20% difference in any site annual mean versus the spatial annual mean.

But, we found ...

- In an analyses of all sites in a metro area versus the corresponding SA average (N=1700+), the median (absolute) difference was only 5%. In less than 25% of all cases was the difference greater than 10%. The current SA criterion of 20% was between the 90th and 95th percentile.

PM_{2.5} - 2006 NAAQS Changes Spatial Averaging

*Hence, the following
changes ...*

2006 Criteria

1. Minimum of **0.9 seasonal (quarterly)** correlation among sites
2. No more than **10%** difference in any site annual mean versus the spatial annual mean.
3. All SA sites should be affected by the same emission sources. **(unchanged)**

FYI – 12 areas met the first 2 criteria (w/ 2001-2003 data).

PM_{2.5} - 2006 NAAQS Changes Spatial Averaging

*What's the bottom
line?*

2006 Criteria

Any area desiring to use spatial averaging to show attainment of the annual standard (15 $\mu\text{g}/\text{m}^3$) must meet the new criteria (for 3 consecutive years)

FYI – Birmingham is the only NA area currently using spatial averaging.

PM_{2.5} - 2006 NAAQS Changes

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park, NC 27711

EPA-454/R-99-008
April 1999

Air

GUIDELINE ON DATA HANDLING CONVENTIONS FOR THE PM NAAQS

Focus on Fine Particles – Monitoring Issues

- $PM_{2.5}$ FRM
- Federal Equivalent Methods, Approved Regional Methods
- $PM_{2.5}$ Minimum Monitoring Network Requirements
- Design Criteria for $PM_{2.5}$

PM_{2.5} NAAQS and Monitoring – Important Dates

- September 21, 2006 - **Final Rule** signed by EPA Administrator
(consent agreement required signature by September 27, 2006)
- October 17, 2006 - PM NAAQS and Monitoring Rules Published in the Federal Register
- December 18, 2006 - Rules become effective
 - New criteria for approval of Federal Equivalent Methods and Approved Regional Methods
 - Removal of required reporting of certain PM_{2.5} monitoring parameters.
- **January 1, 2007**
 - Sites within 5 percent of daily PM_{2.5} NAAQS must sample every day.
 - Field blanks collected must be reported to AQS
- **July 1, 2007 - Annual monitoring plan.**
 - 120 Days After Annual Plan Submittal - Regional Administrator must approve/disapprove the annual plan.
 - Requires public comment, if the State did not provide a comment process.
- **January 1, 2008 – Any new required PM_{2.5} monitoring sites must start**

PM_{2.5} Federal Reference Method Update

- EPA has finalized four improvements to the PM_{2.5} FRM
 1. Very Sharp Cut Cyclone (VSCC) as an approved second stage separator for PM_{2.5} in addition to current WINS
 2. Use of Dioctyl Sebacate (DOS) oil as an alternative oil in the WINS

VSCC



**Partisol-Plus Model 2025
Sequential Air Sampler**



**BGI PQ200
PM_{2.5} FRM**

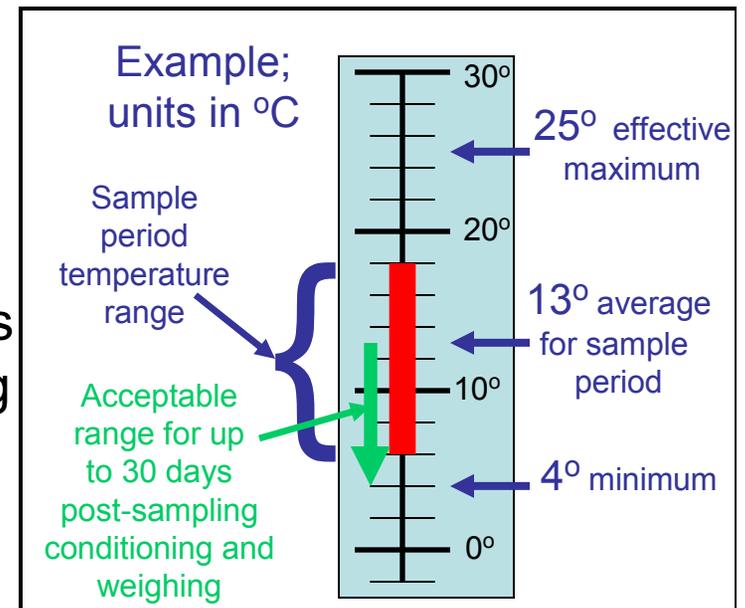


PM_{2.5} Federal Reference Method Update - continued

- Extended filter recovery extension time from 96 hours → 177 hours (7 days, 9 hours)

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Sample Days									
Previous Recovery Period									
New Recovery Period									

- Modified filter transport temperature and post-sampling time requirements for final laboratory analysis; filter transport temperature maintained below average ambient temperature during sampling allows up to 30 days for post-sampling conditioning and weighing.



PM_{2.5} Federal Reference Method Data Reporting Requirements

Information to be Provided	Source of Information	Units	Frequency of Reporting
Concentration	Calculated	µg/m³	Each sample
Average ambient Temperature for the sample period	Sampler	°C	Each sample
Average Barometric Pressure for the Sample Period	Sampler	mm Hg	Each Sample
Field Blanks	Calculated	µg	Each collected field blank
Flow rate, 5-min. average out of spec (FLAG)	Sampler	On/off	Only if applicable
Filter Temperature differential, 30-second interval out of spec. (FLAG)	Sampler	On/off	Only if applicable
Elapsed Sample Time, out of spec. (FLAG)	Sampler	On/off	Only if applicable

Note: other non-sampler flags may be necessary for reporting, as applicable.

New Procedures for Approval of Federal Equivalent Methods (FEMs) ($PM_{2.5}$ and $PM_{10-2.5}$)

- Federal Equivalent Method's for both $PM_{2.5}$ and $PM_{10-2.5}$
 - Three classes of equivalent methods ranging from method with minor deviations from the FRM as Class I to continuous methods as Class III
 - A filter-based dichotomous method would be categorized as a Class II method
- Testing for both $PM_{2.5}$ and $PM_{10-2.5}$
 - Class II - Two sites from list below, one east and one west in one season each
 - Class III – required at four sites (two seasons at test site A, winter season only at test sites B and C, summer season only at test site D)
- Test Sites
 - Site A – Los Angeles basin or California Central Valley - characterized by high nitrates and semi-volatile organic pollutants – winter and summer.
 - Site B – Higher elevation Western U.S. city – characterized by cold weather, winds and dust. – winter only.
 - **Site C – Mid-western city – characterized by substantial temperature variation and high nitrates – winter only.**
 - Site D – Northeastern to Mid-Atlantic – characterized by high sulfate and high relative humidity – summer only.

Approved Regional Methods (ARMs) for PM_{2.5}

- PM_{2.5} continuous method approved for use within a State, local, or Tribal agency used to meet multiple monitoring objectives such as NAAQS, Air Quality Index, and forecast validation.
- Testing Criteria
 - Uses same performance criteria as Class III methods; however, flexibility to demonstrate sample precision
 - Testing occurs at subset of sites in network within which it's intended to be used
- Approvals
 - Initial ARM application approved through Office of Research & Development.
 - Subsequent applications for method in another geographic region approved by EPA Regional Office.
 - All procedures (including proposed use of data transformations) must be fully described in Quality Assurance Program Plan accompanying ARM application.

New Procedures for Approval of FEMs ($PM_{2.5}$ and $PM_{10-2.5}$) and ARMs ($PM_{2.5}$)

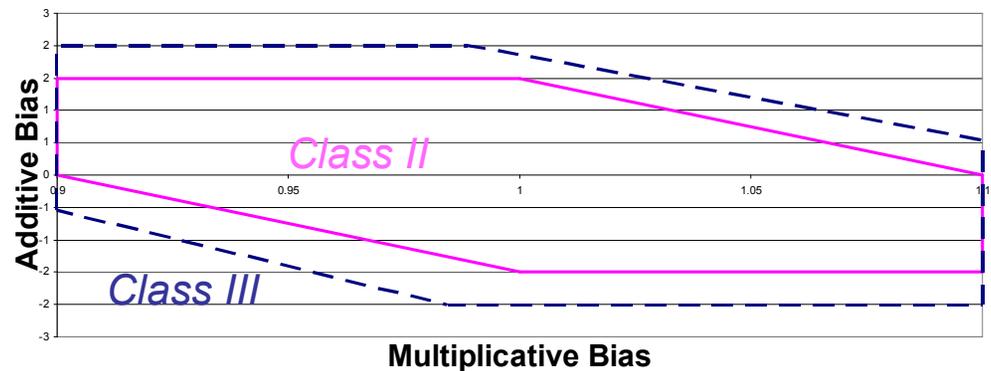
	FRM	FEM Class II	FEM Class III	ARM
Defined as	Method defined by Appendix L to Part 50 for $PM_{2.5}$ or Appendix O for $PM_{10-2.5}$	Samples collected by filtration, with filter conditioning, and gravimetric analysis, but having substantial design differences from FRM	Having one-hour or less concentrations as well as 24-hour	Continuous $PM_{2.5}$ method approved within a State or local air monitoring network
Design or performance based	Design	Performance	Performance	Performance
Filter/ Continuous	Filter-based	Filter-based	Continuous	Continuous
Time Resolution	24-hour	24-hour	Hourly	Hourly
Network Applicability	National	National	National	Individual Network
Applicable to	$PM_{2.5}$, $PM_{10-2.5}$	$PM_{2.5}$, $PM_{10-2.5}$	$PM_{2.5}$, $PM_{10-2.5}$	$PM_{2.5}$ only

Performance Criteria for Approval of Federal Equivalent Methods ($PM_{2.5}$ and $PM_{10-2.5}$)

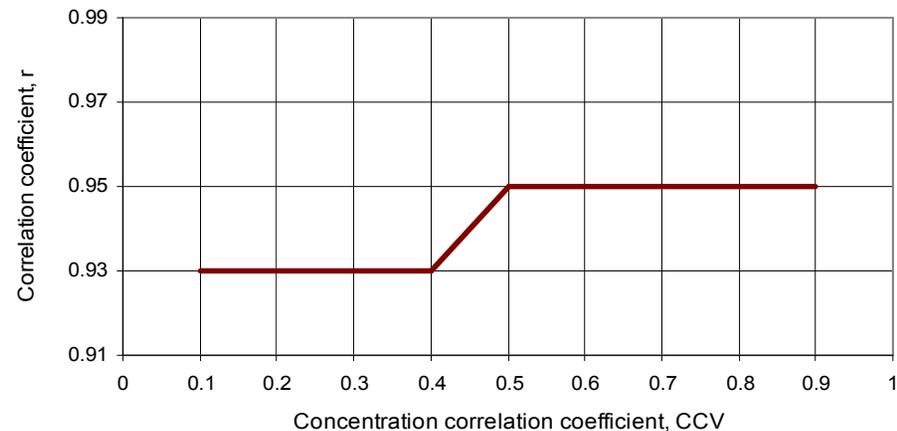
Performance criteria for approval of Class II and Class III methods

- Based on Data Quality Objective Process
 - Considers tradeoffs between several inputs
 - Advantage of continuous methods (Class III) in this process is that they provide higher sample frequency and completeness
- Class III criteria performance criteria also used for ARM designations
- Criteria
 - Linear regression slope (multiplicative bias) and intercept (additive bias)
 - Sampler precision
 - Correlation, based on sample population

$PM_{2.5}$ Equivalency Criteria



Minimum Limits for Correlation Coefficient



PM_{2.5} Minimum Monitoring Network Requirements

There are four types of monitoring requirements for the PM_{2.5} network:

Sample Method	1 - MSA NAAQS Monitoring	2 - Continuous Mass Monitoring	3 - Background and Transport Monitoring	4 - Speciation Monitoring
FRM				
FEM Class II (i.e., dichot)				
FEM Class III (i.e., continuous)				
ARM				
Non-NAAQS Continuous mass				
STN				
IMPROVE				

2. One half (rounded up) of required MSA NAAQS samplers need continuous monitors (does not have to be collocated with FRM's)
3. Background and transport monitors required in each State – with flexibility to use IMPROVE, continuous-mass or nearby States monitor
4. Each State shall continue to conduct speciation at sites designated to be part of the PM_{2.5} Speciation Trends Network

PM_{2.5} Minimum Monitoring Network Requirements

MSA Population^{1,2}	Most recent 3-year design value \geq 85% of any PM_{2.5} NAAQS³	Most recent 3-year design value < 85% of any PM_{2.5} NAAQS^{3,4}
> 1M	3	2
500K – 1M	2	1
50K – <500K	1	0

¹ Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).

² Population based on latest available census figures.

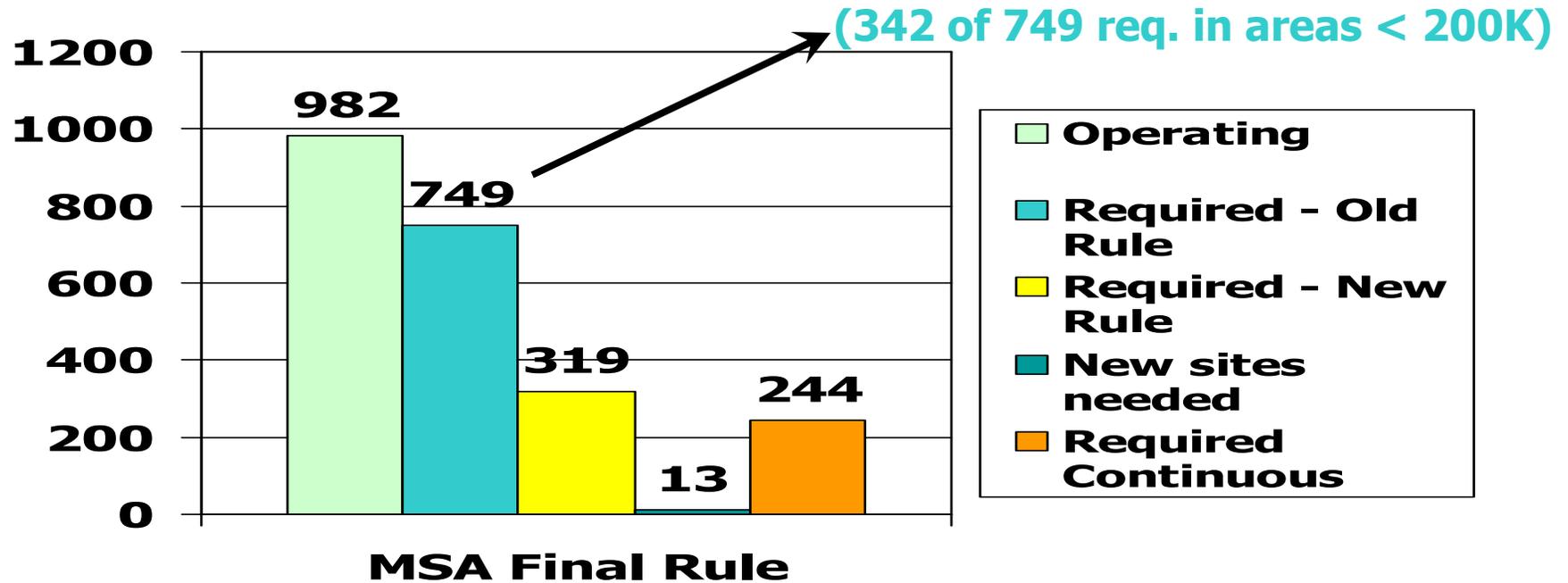
³ The PM_{2.5} National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.

⁴ These minimum monitoring requirements apply in the absence of a design value.

⁵ Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

Deviations from these PM_{2.5} network requirements must be approved by the EPA Regional Administrator.

PM_{2.5} FRM/FEM/ARM Monitoring Sites



Areas where using MSA instead of CSA results in a change in the required number of new sites

Area	Difference in number of required sites
Albany, NY	-1 (csa would require 2 new sites; msa 1)
Greensboro, NC	1
Raleigh, NC	1
San Jose, CA	1

Design Criteria for $PM_{2.5}$

- EPA retained the existing siting criteria for $PM_{2.5}$ which has an emphasis on “population-oriented” sites at neighborhood scale and larger
- **Required monitoring stations or sites must be sited to represent community-wide air quality.**
 - Appendix D to Part 58, Section 4.7.1, (b) “...will typically be at neighborhood or urban-scale; however, in certain instances where population-oriented micro- or middle-scale $PM_{2.5}$ monitoring are determined by the Regional Administrator to represent many such locations throughout a metropolitan area, these smaller scales can be considered to represent community-wide air quality.”*
- For required monitoring stations located to represent community-wide air quality:
 1. **At least one monitoring station is to be sited in a population-oriented area of expected maximum concentration**
 2. For areas with more than one required SLAMS, a monitoring station is to be sited in an area of poor air quality

Design Criteria for PM_{2.5} - Applicability of Scales in Urban Areas

Scale	Micro	Middle	Neighborhood	Urban
Dimensions	Up to 100m	100 m to 0.5k	0.5k to 4k	4k to 50k
Community-Wide	Only when representative of many such locations in the area	Only when representative of many such locations in the area	✓	✓
Population-oriented	Yes, for many cases (e.g., downtown street canyon)	Yes, for many cases (e.g., living near major roadways)	✓	✓
Daily NAAQS	Yes, when population oriented	Yes, when population oriented	✓	✓
Annual NAAQS	No, unless population oriented and Community-wide	No, unless population oriented and Community-wide	✓	✓
Fulfills minimum monitoring requirements	<p><i>Only when acceptable as community-wide</i></p>  <p><i>Applicable</i></p>			