Review of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter

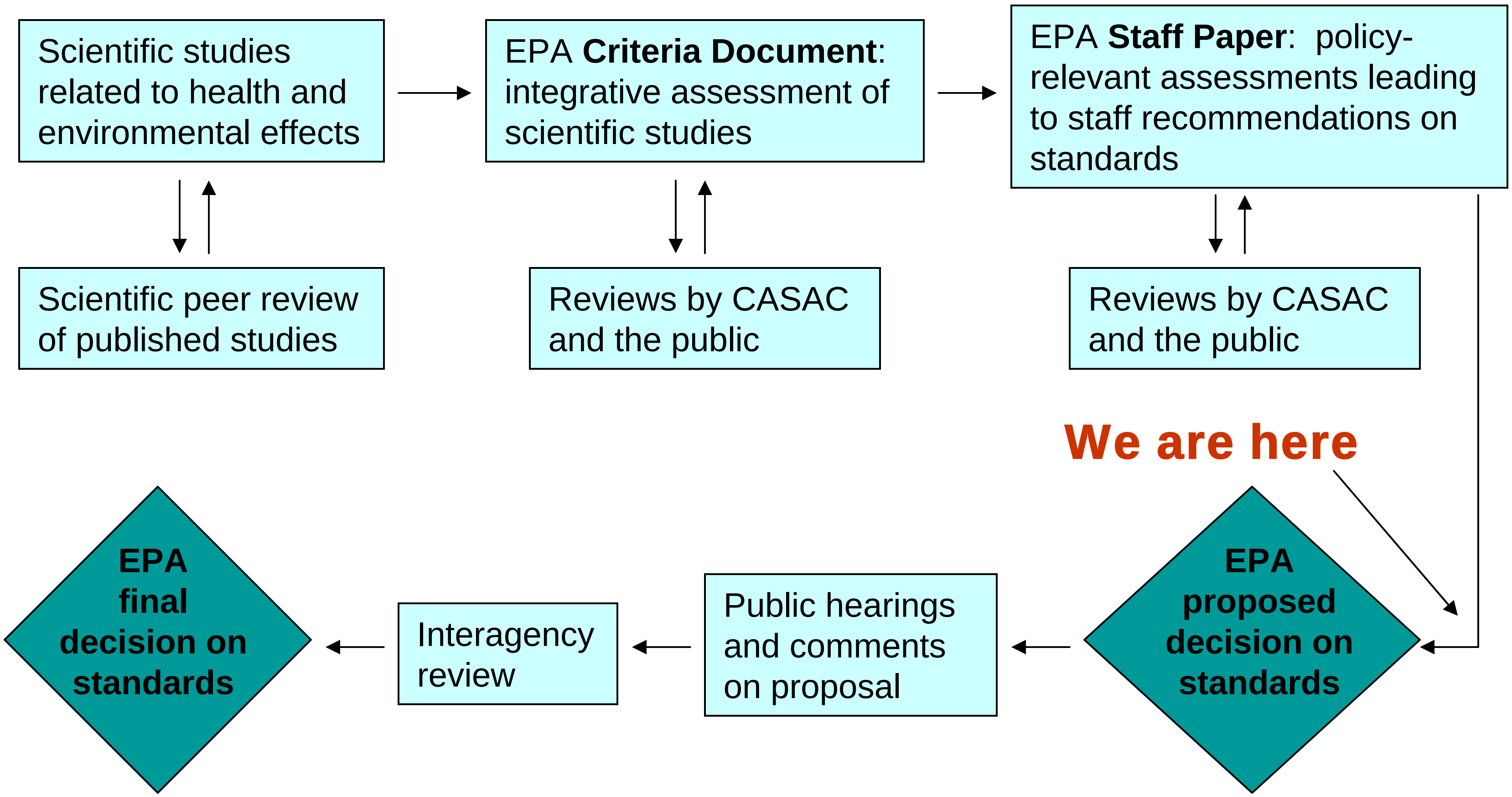
Overview

- We’re nearing the completion of the review of the 1997 standards for particulate matter.
- The decision is an important one for the Nation and must be complete by September 2006.
- This briefing will provide background on how we review air standards and technical and scientific details on particles and their health and environmental effects

Overview of NAAQS Review Process

- **The CAA calls for NAAQS for common air pollutants, based on the latest scientific criteria.**
- **"Primary" standards are those 'requisite' to 'protect public health' with an 'adequate margin of safety.'**
- **"Secondary" standards protect public welfare and the environment (visibility, crops, vegetation, wildlife, buildings & national monuments, climate).**
- **EPA has set NAAQS for six common air pollutants: ground-level ozone (smog), particulate matter, carbon monoxide, lead, nitrogen dioxide, sulfur dioxide.**
- **EPA considers only human health and environmental effects in *setting* the NAAQS.**
- **EPA considers costs and time to attain cleaner air in *achieving* the standards.**
- **The CAA requires EPA to review the scientific criteria and these standards at least once every five years, with advice from the Clean Air Scientific Advisory Committee (CASAC).**

PM NAAQS Review - Process



PM NAAQS Review - Schedule

- Final PM Air Quality Criteria Document– October 2004
- Final PM Staff Paper – June 2005
- CASAC letters and recommendations – June and September 2005
- Rulemaking on PM NAAQS:
  - ***Federal Register* proposal to be signed by December 20, 2005**
  - **Public comment period: 90 days**
  - **Final *Federal Register* notice to be signed by September 27, 2006**
  - **Simultaneous Rulemakings:**
    - **PM NAAQS, FRM, & Data Handling (Part 50)**
    - **Ambient Air Monitoring Regulations: Requirements for Reference and Equivalent Methods, Network Design Requirements (Parts 53 & 58)**
    - **Exceptional & Natural Events**

Web address for Staff Papers:

http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_sp.html

Anatomy of a NAAQS

- Four major components of standards that determine degree of protection:
  - **Indicator**: e.g., PM_{10}, $PM_{2.5}$, O_3, SO_2
  - **Averaging Time**: e.g., 1-hr, 24-hr, annual average
  - **Form**: e.g., number of exceedances, percentile, mean
  - **Level**: e.g., 15 $\mu g/m^3$

History of Particulate Matter NAAQS

- **1971** – EPA promulgates NAAQS for "total suspended particulate" (particles smaller than ~25-45 µm in diameter)
- **1987** – EPA revises PM NAAQS, changing the indicator from TSP to PM_{10} to focus on "inhalable" particles (< 10 µm)
- **1997** – EPA revises PM NAAQS to focus separately on the "fine" and "coarse" fractions of PM_{10}
  - New standards established for "fine" particles < 2.5 µm in diameter ($PM_{2.5}$)
  - PM_{10} standards retained to focus on "coarse fraction" (particles between 2.5 and 10 µm in diameter)
- A number of events delayed the implementation of PM2.5.
  - Industry organizations and state governments challenged EPA in the U.S. District Court.
  - In 2001, the U.S. Supreme Court upheld EPA's authority under the Clean Air Act to set standards. Several unresolved issues were sent back to the District Court.
  - In 2002, the District Court rejected all remaining legal challenges to EPA's 1997 standards for PM2.5.
- **2004-** EPA designated 224 counties, as well as DC, as not meeting the standards for PM2.5.
- **2005-6** – Complete review/revision of PM NAAQS (process underway)

PM Components: fine and coarse

Fine Particles

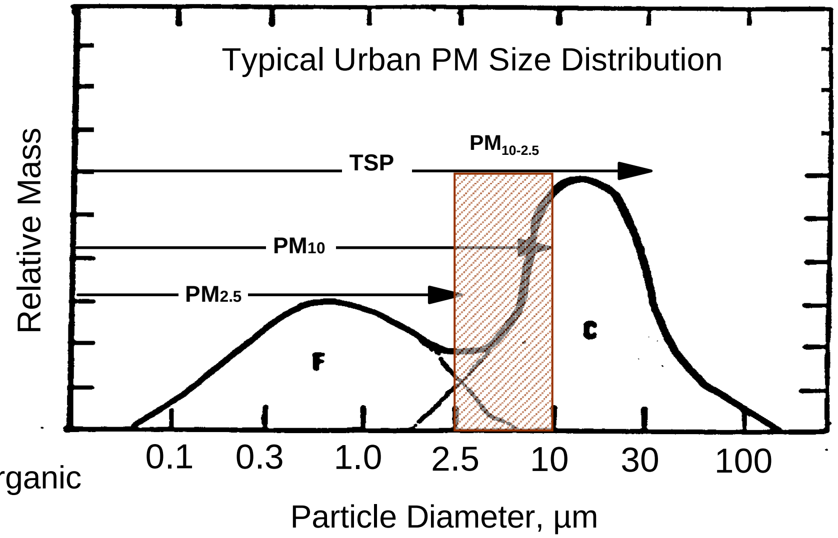
Combustion, gases to particles
Sulfates/acids
Nitrate
Ammonium
Organics
Carbon
Metals
Water

Sources

Coal, oil, gasoline, diesel, wood combustion
Transformation of SOx, NOx, organic gases including biogenics
High temperature industrial processes (smelters, steel mills)
Forest fires

Exposure/Lifetime

Lifetime days to weeks, regional distribution over urban scale to 1000s of km



Coarse Particles

Crushing, grinding, dust
Resuspended dusts (soil, street dust)
Coal/oil fly ash
Aluminum, silica, iron-oxides
Sea salt
Tire wear
Biological Materials (Pollen, mold, plant/insect fragments)

Sources

Resuspension of dust tracked onto roads
Suspension from disturbed soil (farms, mines, unpaved roads
Construction/demolition
Industrial fugitives
Biological sources, sea spray

Exposure/Lifetime

Coarse fraction (2.5-10) lifetime of hours to days, distribution over smaller scales up to 100s km

Public Health Risks are significant

1997 review found PM linked to:

- **Premature death from heart and lung disease**
- **Aggravation of heart and lung diseases**
  - Hospital admissions
  - Doctor and ER visits
  - Medication use
  - School and work absences

….*all at levels permitted by the old PM10 NAAQS*

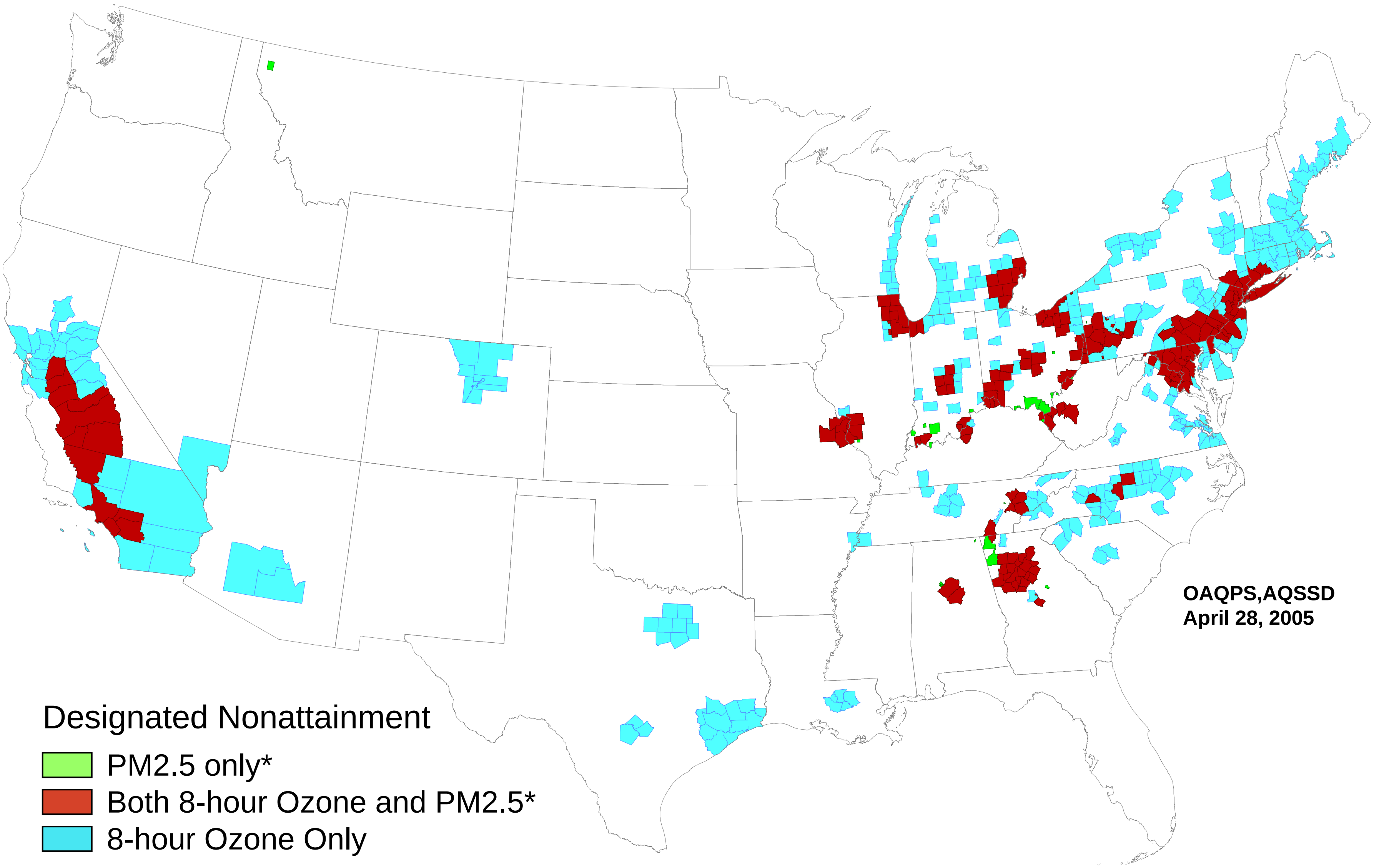
- **And possibly to:**
  - Lung cancer deaths
  - Infant mortality
  - Developmental problems, such as low birth weight, in children
- Fine particles ($PM_{2.5}$) appeared to present the most significant risks, including tens of thousands of premature deaths

1997 PM NAAQS Decision

- New standards established for $PM_{2.5}$
  - "Generally controlling" annual standard set at 15 µg/m^3
    - Averaged over 3 years, with allowance for spatial averaging of monitors within certain constraints
  - "Supplemental" 24-hour standard set at 65 µg/m^3, to protect against peak concentrations that might occur due to strong local or seasonal sources over limited areas and/or time periods
    - Annual 98th percentile, averaged over 3 years

- PM_{10} standards were retained to focus on "coarse fraction" particles (between 2.5 and 10 µm)
  - 50 µg/m^3, annual average
  - 150 µg/m^3, 24-hr average, but form of standard changed to 99th percentile

PM2.5 and Ozone Nonattainment Areas



* For PM2.5, the designated partial county areas are shown as actual boundaries designated.

What's new since 1997? . . . an unprecedented number of new studies

- Hundreds of new short-term exposure studies
  - New outcomes: physician visits, cardiovascular effects (myocardial infarction, biomarkers), and possibly developmental effects
  - New multi-city and source apportionment studies
- Extensive reanalyses/validation and extended analyses of key long-term exposure studies
  - New evidence of association with lung cancer mortality
- Intervention studies reporting health improvement with reduction in PM and gaseous pollutants
- Controlled human exposure studies and toxicologic studies provide insights into potential mechanisms
- Exposure studies
- Greatly expanded risk assessment
  - Based on data from extensive $PM_{2.5}$ monitoring network and results from new health studies

Staff recommendations - indicator and averaging times

- Current indicator based on mass, using size cutpoint at 2.5 µm
  - Staff concludes that mass-based indicator remains appropriate
    - Health studies implicate various PM components (sulfates, nitrates, elemental carbon, organic compounds, metals) are linked with adverse effects
    - Likely that different components more closely linked with different effects
    - No basis to exclude any components
    - Staff emphasizes need for continued research on effects from different PM components, PM from various sources, or different size classes (e.g., ultrafine particles)
  - *Staff concludes that size cut of 2.5 µm remains appropriate*
  - More completely captures fine particles under all conditions in U.S., particularly under high humidity conditions, while recognizing that some small coarse particles may be captured
- *Staff concludes that annual and 24-hour averaging times remain appropriate*

Staff recommendations on primary $PM_{2.5}$ standards

- Consideration should be given to alternative suites of $PM_{2.5}$ standards:
  - An *annual standard at the current level of 15 µg/m³* together with a revised *24-hour $PM_{2.5}$ standard in the range of 35 to 25 µg/m³*, based on a 98th percentile form for a standard set at the middle to lower end of this range, or a 99th percentile form for a standard set at the upper end of this range

    OR

  - A revised *annual $PM_{2.5}$ standard, within the range of 14 to 12 µg/m³*, together with a revised *24-hour $PM_{2.5}$ standard in the range of 40 to 30 µg/m³*. Staff judges that a suite of standards that includes either the annual or 24-hour standard, or both, set at the middle to lower end of these ranges could provide an appropriate degree of health protection

CASAC recommendations on primary $PM_{2.5}$ standards

- CASAC found staff recommendations “scientifically well-reasoned” and advised that primary $PM_{2.5}$ standards should be revised “to provide increased public health protection”
  - Consensus in agreement with staff recommendations that focused primarily on lowering the 24-hr $PM_{2.5}$ standard
    - In addition, Panel “did not endorse the option of keeping the annual standard at its present level”
  - Most Panel members favored a 24-hr standard in the range of 35 to 30 $\mu g/m^3$ together with a revised annual standard in the range of 14 to 13 $\mu g/m^3$
  - Most Panel members favored continued use of 98th percentile form, along with continued use of annual and 24-hour averaging times

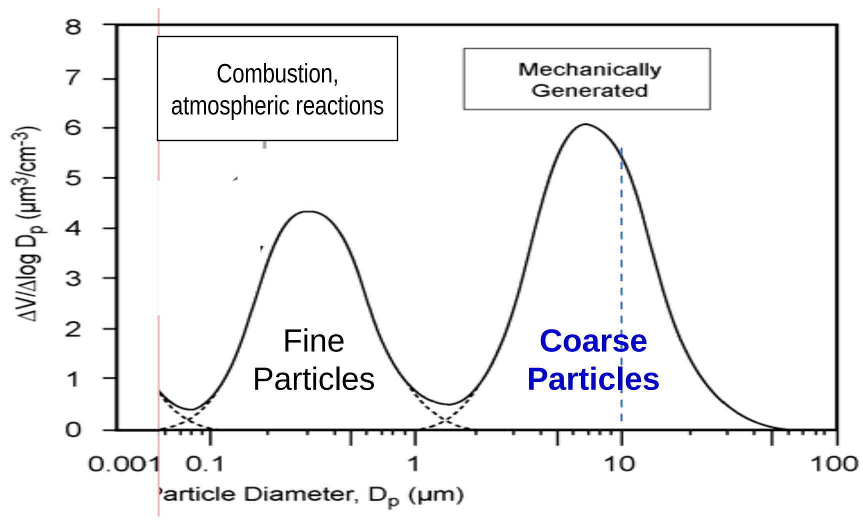
Staff/CASAC recommendations for secondary PM NAAQS to address visibility impairment

- Staff recommends revising current standards to provide increased and more targeted protection primarily in urban areas from visibility impairment related to fine particles
- Staff recommends that a revised secondary standard consider:
  - An averaging time of 4 to 8 daylight hours
  - A level in the range of 30 to 20 µg/m^3, depending in part on the form of the standard
  - A percentile-based form, focusing on a range from the 92^{nd} to the 98^{th} percentile of the annual distribution of daily short-term $PM_{2.5}$ concentrations, averaged over 3 years
- CASAC panel members recommended considering a 92^{nd} to 98^{th} percentile form, combined with a level toward the upper-end of the proposed range of 30 to 20 µg/m^3
- *Decision on secondary linked to decision on health based NAAQS*

Basis for 1997 decisions on PM_{10} standards . . . built upon earlier PM NAAQS reviews

- 1971: set NAAQS for “total suspended particulate” (particles smaller than ~25-45 µm in diameter)
- 1987: revised PM NAAQS, changing the indicator from TSP to PM_{10} to focus on “inhalable” or “thoracic" particles (< 10 µm)

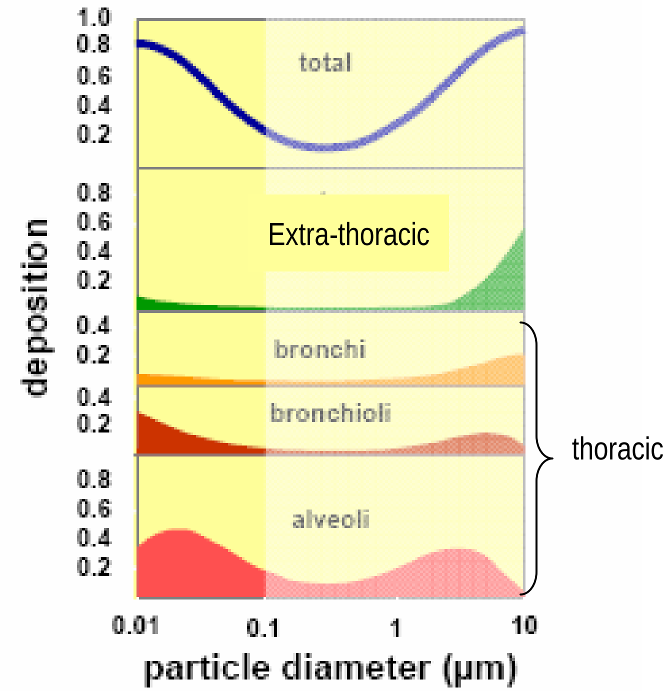
“Bimodal” Distribution of Ambient PM:



Sulfates, nitrates, ammonium, elemental carbon, organics, metal compounds

Crustal materials, road dust, biological materials

Particle Deposition in Humans:

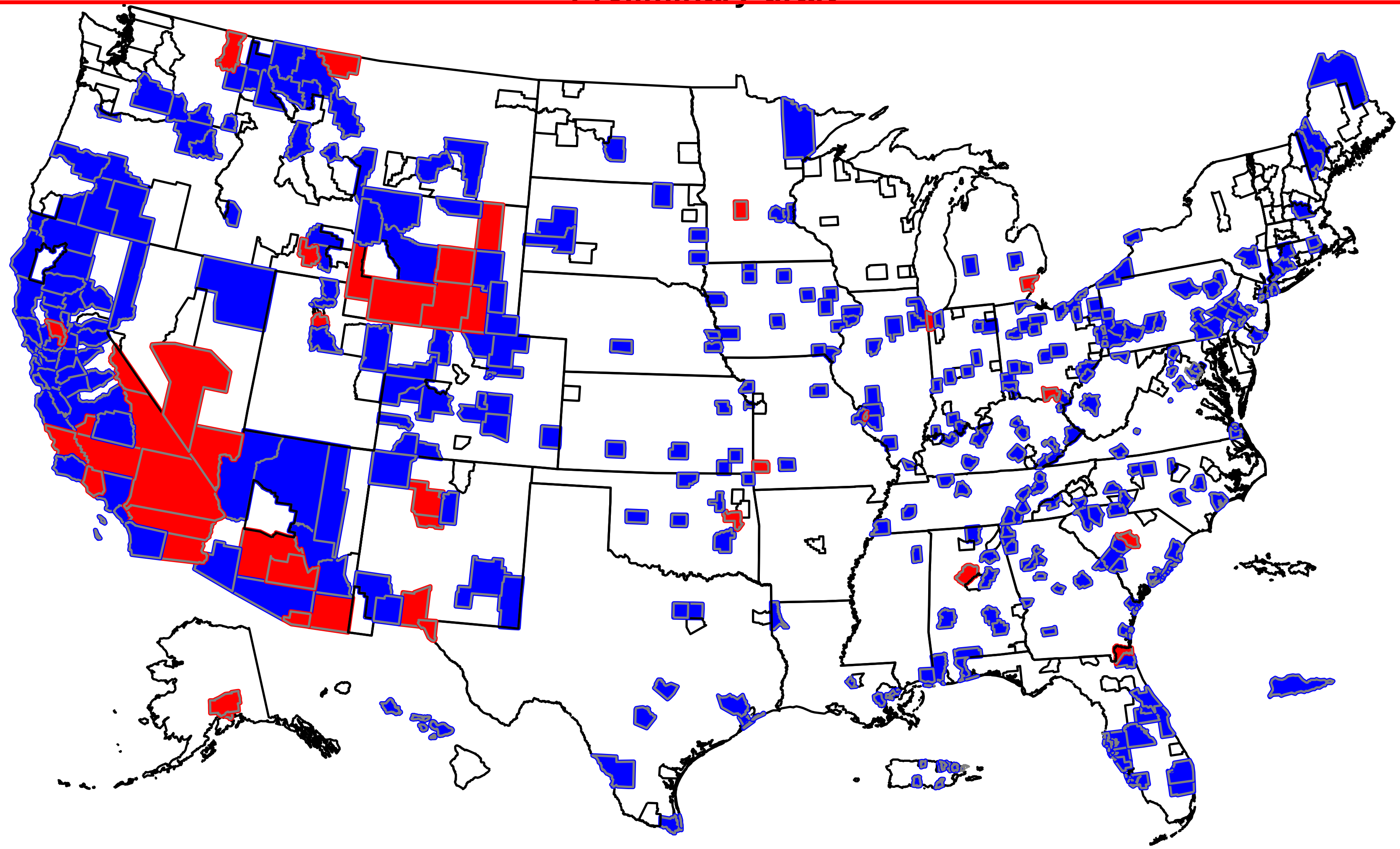


ICRP 66 (1994); MPPDep (2000): based on experimental data

County-level status for PM_{10} NAAQS, 2002-2004

based on <u>24-hour standard only (150 ug/m3, 1 expected exceedence)</u>

Preliminary draft



Concentration ug/m3 — **Meets** — **Does Not Meet**

Note: Based on AQS data as of July 8, 2005. Excludes Regionally-concurred flagged values.

1997 Decision on PM10 NAAQS

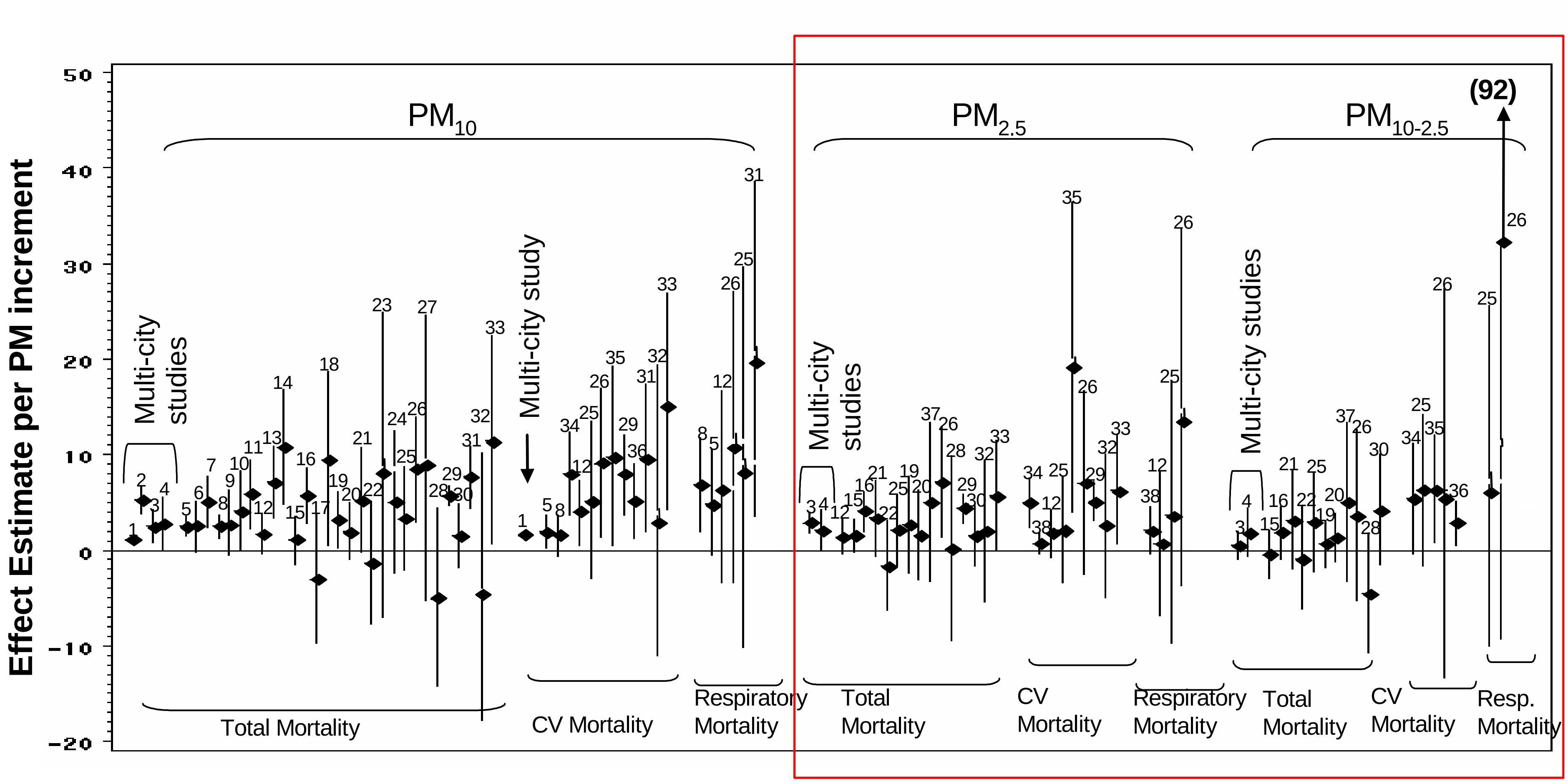
- In conjunction with new $PM_{2.5}$ standards, generally strong public and CASAC support for retaining standards to protect against the effects of coarse fraction particles ($PM_{10-2.5}$)
  - Dosimetry evidence shows deposition in lower respiratory tract
  - Limited PM_{10} short-term exposure studies linked coarse fraction particles to respiratory effects
  - Possible long-term exposure effects considered based on potential build-up in the lung
- PM_{10} retained as indicator
  - Only health studies of clear relevance used PM_{10} in areas where coarse fraction was dominant
  - Very limited $PM_{10-2.5}$ air quality data; but extensive PM_{10} data
- Both 24-hr and annual PM_{10} standards retained at same levels
  - Only evidence from 2 studies in areas that exceeded current standards
- Form of 24-hr standard revised to a concentration-based form (99th percentile), to retain generally equivalent level of protection
  - Court found “ample support” for decision to regulate coarse particles, but . . .
  - Vacated revision, finding PM_{10} to be a poorly matched indicator for coarse fraction particles because it includes fine particles

Current review: approach based on new information

- Focus on new information indexed by $PM_{10-2.5}$
  - Growing, but still limited, body of $PM_{10-2.5}$ epidemiologic evidence
  - Much more $PM_{10-2.5}$ air quality data

- New studies report statistically significant associations between short-term exposure to $PM_{10-2.5}$ and <u>morbidity</u>, including hospitalization and respiratory symptoms
  - Magnitudes of associations similar to those for $PM_{2.5}$, but generally less precise estimates, likely due to increased exposure measurement error

U.S. and Canadian studies of associations between short-term PM exposure and mortality



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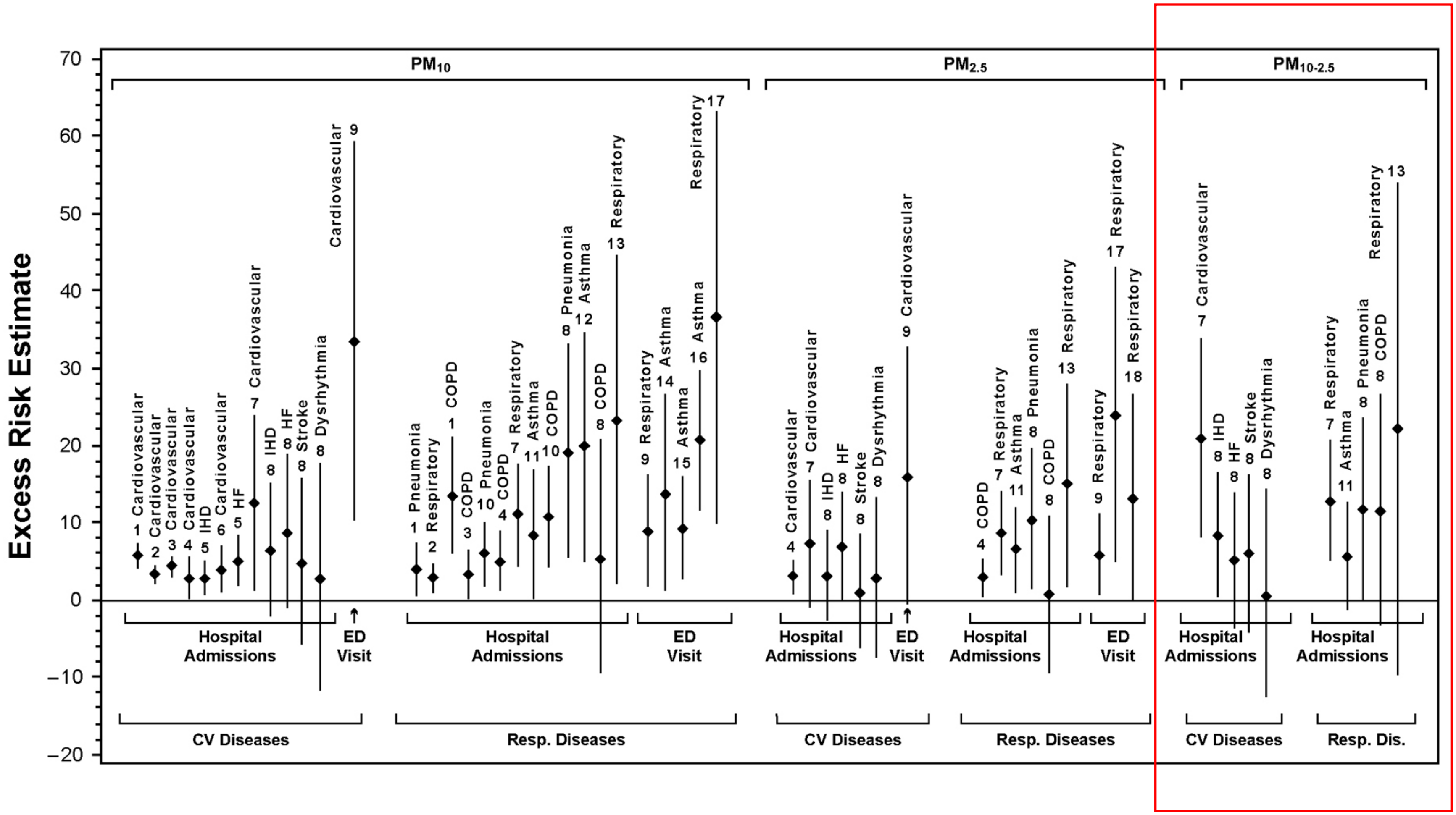


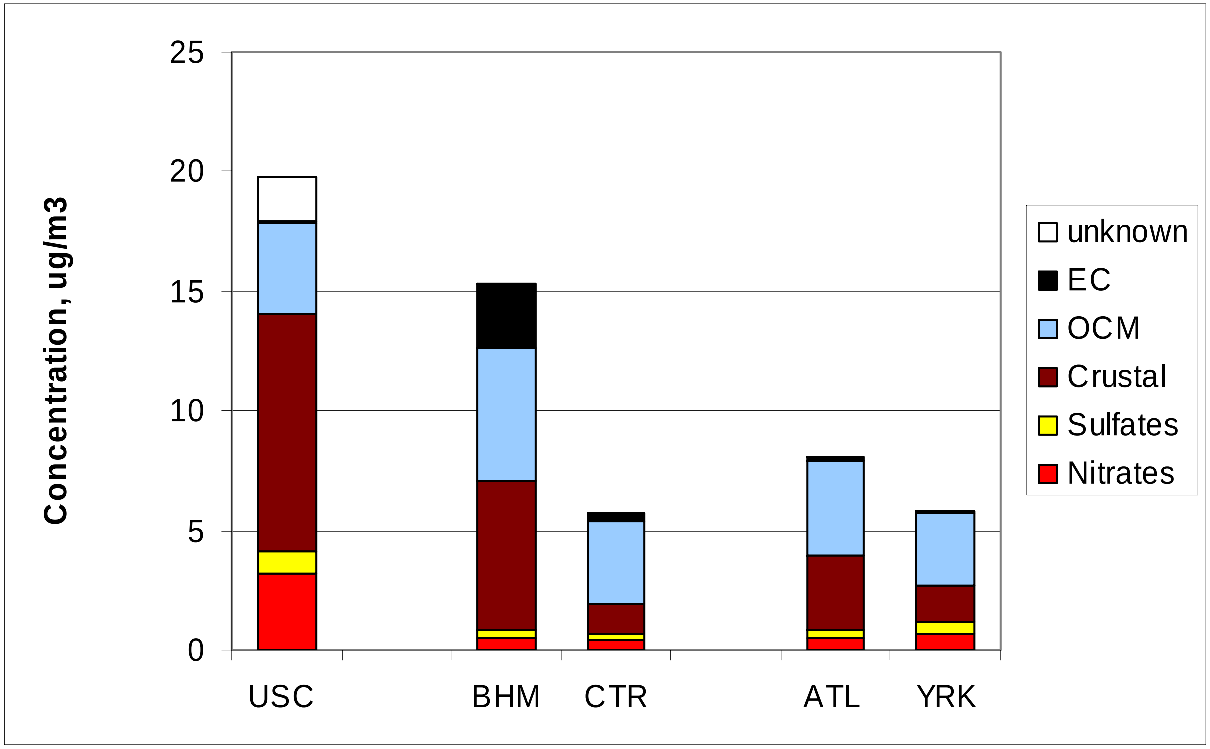
Considerations in defining an indicator for thoracic coarse particles

- Most obvious choice is size-differentiated, mass-based indicator used in epidemiologic studies, $PM_{10-2.5}$
  - Upper size cut consistent with dosimetric evidence
  - Lower size cut consistent with choice of $PM_{2.5}$ for fine particles
  - Insufficient information available to define an indicator solely in terms of other metrics, such as specific components
  - Available epidemiologic evidence quite limited and with large uncertainties, reflective of more heterogeneous spatial distribution and chemical composition
- Evidence for focus on coarse particles common in urban environments
  - Toxicologic evidence suggests effects with several components of particles typical of urban areas (e.g., road dust particles), but not particles of geologic origin (e.g., Mt. St. Helens dust)
  - Epidemiologic studies (e.g., Spokane) find no association between mortality and PM_{10} from wind storms (when natural crustal particles predominate)
  - Lack of epidemiologic evidence related to thoracic coarse particles typical of non-urban areas

Considerations in defining an indicator (cont.)

- Also considered evidence related to coarse particles in communities predominantly influenced by agricultural or mining activities
  - Absence of evidence at community-level exposures (in contrast to effects reported at occupational exposure levels)
  - Unlikely to be contributing to effects observed in recent urban studies
- Clear distinctions noted in the nature of coarse particles found in urban and non-urban/rural areas, leading to consideration of more narrowly defined indicator that focuses on particles characteristic of sources generally present in urban areas
  - Higher exposures in urban than in near-by rural areas, due to local urban sources (resuspended dust from high traffic-density paved roads; industrial sources)
  - Urban coarse particles enriched by contaminants (e.g., metals, other air toxics) not commonly found in natural geologic crustal materials typical of rural particles
- Staff concludes that, given differences in composition and effects evidence, it is not appropriate to assume that effects related to the mix of coarse particles commonly found in urban environments would also apply to particles characteristic of rural areas

Coarse Particle Composition



Average $PM_{10\text{-}2.5}$ composition for Los Angeles and two eastern urban-rural pairs. Based on USC Supersite data (10/2002 to 9/2003), and Birmingham, AL (BHM, urban), Centerville, AL (CTR, rural), Atlanta, GA (ATL, urban) and Yorkville, GA (TRK, rural) monitoring sites in the Southeastern Aerosol Research and Characterization (SEARCH) Study, 4/2003-12/2003. In general, urban coarse particles have higher concentrations and more components from urban sources such as combustion and industrial activities than rural sites. Western sites also show higher crustal contributions.

Considerations in recommending ranges of levels

- Evidence of effects associated with short-term exposure to thoracic coarse particles: morbidity
  - Significant associations reported with respiratory or cardiovascular hospitalization in areas (e.g., Detroit, St. Louis, Seattle) with 98th percentile $PM_{10-2.5}$ values in the range of 30-40 µg/m^3
  - Uncertainty in population exposure characterized by ambient $PM_{10-2.5}$ levels
    - Greater spatial variation in $PM_{10-2.5}$ concentrations (than for $PM_{2.5}$) influences interpretation of epidemiologic study results as a basis for recommending standard levels
    - Detroit example
      - Time-series study used $PM_{10-2.5}$ concentrations obtained from Windsor monitors
      - PM data well-correlated with other Detroit monitors, but analysis suggests that Windsor levels are generally less than half the levels recorded at urban-center Detroit monitors, though more similar to suburban areas well outside the city

Considerations in recommending ranges of levels (cont.)

- Evidence of effects associated with short-term exposure to thoracic coarse particles: mortality
  - Associations with mortality less consistent than with morbidity; reported only in areas with relatively high concentrations
    - Significant or nearly-significant associations reported in several areas (Steubenville, Phoenix, Coachella Valley) where 98th percentile $PM_{10-2.5}$ values ranged from 53 to 107 µg/m^3
    - No significant associations reported in a number of areas where 98th percentile $PM_{10-2.5}$ values were generally below 50 µg/m^3
  - Uncertainty in interpreting $PM_{10-2.5}$ levels in epidemiologic studies remains, as in morbidity studies
    - Coachella Valley example
      - Monitor in one community with highest levels was used in study, although a portion of study population likely experienced appreciably lower exposure levels
      - $PM_{10-2.5}$ measurements used in epidemiologic study appear to represent concentrations at the high end of levels for communities in the Coachella Valley

Considerations in recommending ranges of levels (cont.)

- Based on close look at epidemiologic studies, evidence suggests consideration down to at least 50 µg/m^3
  - Recognizes that exposure measurement error is potentially quite large
  - Consideration of lower levels, to provide a margin of safety against morbidity effects that may possibly occur at such low levels, may not be warranted
- An even more cautious or restrained approach to interpreting epidemiologic evidence led to staff consideration of a standard that would provide generally "equivalent" protection to that afforded by current standards
  - A $PM_{10-2.5}$ level of approximately 60 µg/m^3 (98^{th} percentile value) would be roughly equivalent on average to a PM_{10} level of 150 µg/m^3 (one-expected-exceedence form)
  - Comparison of areas that would likely not meet possible alternative standards indicates that a $PM_{10-2.5}$ standard of about 65-70 µg/m^3 (98^{th} percentile form) would likely provide protection for approximately the same number of counties or number of people as the current PM_{10} standards

Staff recommendations based on initial CASAC advice

- Replace PM_{10} indicator with a more narrowly-defined indicator of urban thoracic coarse particles, $UPM_{10-2.5}$
  - Primarily based on particle size, but also on recognition that coarse particles from urban-type sources have been associated with health effects
  - Would not include particles generally present in rural areas typically characterized by high proportions of natural geologic materials (e.g., windblown dust; coarse particles from mining or agricultural operations)
- Specify minimum monitoring network design requirements and exceptional/natural events rule consistent with intent of new indicator
- Alternative levels for a 24-hour standard of approximately 50 to 85 $\mu g/m^3$ (depending in part on the form of the standard)
  - More precautionary approach would focus on lower end of range taking into account levels reported in epidemiologic studies
  - Placing more weight on uncertainties would focus on upper end of range
- Little basis for retaining an annual standard

Final CASAC advice (September 15, 2005 letter)

- Panel found Staff Paper to be responsive to previous advice
- Committee agrees with summary of scientific data
  - Several studies provide convincing data of associations with morbidity endpoints; mortality associations suggestive
  - Coarse particles in urban or industrial areas are likely to be enriched by anthropogenic pollutants inherently more toxic than windblown crustal material
  - Most concurred that scarcity of data on rural toxicity makes it necessary to base standard on known toxicity of urban-derived coarse particles
  - *While data are limited "several US and Canadian studies do provide convincing data that there is an association between short-term exposure to PM10-2.5 and various morbidity endpoints. Associations with mortality endpoints were suggestive but not as convincing*"
- General concurrence among Panel members on the need for a standard for particles between 2.5 and 10 µm (17 of 17 members)
  - Supports 24-hour averaging time; agrees that annual standard not warranted
  - Strongly recommends use of 98th percentile form
- Most but not all Panel members support an urban-oriented indicator
  - Considered as a surrogate for urban-type components that differ in composition from natural crustal particles; research needed
  - However, some recommended a $PM_{10\text{-}2.5}$ indicator accompanied by monitoring and exceptional-events guidance to emphasis urban influences
- Agreement that staff presented reasonable justification for range of levels
  - Most members favored levels at upper end of range
  - Several supported lower end of range