PM Health Protection Symposium
(Advisory Council Meeting of October 28, 2019)

Chair Stan Hayes
Advisory Council
December 9, 2019
PM Focus:
Context

• Following three years of intense wildfire smoke, focus on reducing diesel PM emissions, and conclusion that PM is overwhelming health risk driver in Bay Area air

• Air District asked Advisory Council to focus on PM

• Provide Advisory Council’s take on latest and best science, in science-affirming way

• Assist Air District to identify those further PM measures that would most move public health needle, especially in most impacted communities
PM Symposia: Overview

- Convened by Advisory Council as *series of meetings*
- Engage *nationally-recognized experts*, including leading experts previously engaged at the Federal level
- **Support Air District** in identifying health-focused “target” guidelines based on latest science, beyond standards already in effect
- Facilitate **Advisory Council feedback** on Air District planning
- Include **local stakeholders**
- Provide **national leadership**
Key Points

• The National Ambient Air Quality Standard (NAAQS) Science Review Process Worked Well Until 2017

• EPA Administrators Pruitt and Wheeler Have Broken the Process

• Particulate Matter Science Review By the EPA Clean Air Scientific Advisory Committee (CASAC) is Highly Deficient: Appropriate to Look Elsewhere

• Disbanded CASAC PM Review Panel Reconvened Itself

• Key Findings of the Independent Particulate Matter Review Panel
Particulate Matter: Spotlight on Health Protection
### Agenda Items

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
<th>Location</th>
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<tbody>
<tr>
<td>8:30 AM</td>
<td>Registration/Coffee and light breakfast</td>
<td>Atrium</td>
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<tr>
<td>9:00 AM</td>
<td>Welcome</td>
<td>Board Room</td>
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<tr>
<td>9:25 AM</td>
<td>PM Health Effects Panel</td>
<td>Board Room</td>
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<td>11:05 AM</td>
<td>Break</td>
<td>Atrium</td>
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<tr>
<td>11:15 AM</td>
<td>Joint Discussion: Health Effects Panel</td>
<td>Board Room</td>
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<td>12:00 PM</td>
<td>Lunch with Keynote Speaker – Former EPA Administrator Gina McCarthy</td>
<td>Yerba Buena</td>
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<td>1:15 PM</td>
<td>PM Exposure &amp; Risk Panel</td>
<td>Board Room</td>
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<td>2:55 PM</td>
<td>Break</td>
<td>Atrium</td>
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<tr>
<td>3:10 PM</td>
<td>Joint Discussion: Exposure &amp; Risk Panel</td>
<td>Board Room</td>
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<tr>
<td>4:00 PM</td>
<td>Advisory Council Deliberation</td>
<td>Board Room</td>
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### Additional Information

- This is a meeting of the BAAQMD Advisory Council.
- Public comment will take place during welcome remarks.
- For ADA related assistance, please contact Aerena Flores at afl ores@baaqmd.gov.

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**Particulate Matter: Spotlight on Health Protection**

- ~160 registrants
- 2 panels
  - PM Health Effects
  - PM Exposure & Risk
- 9 leading experts
Gina McCarthy

• **Former EPA Administrator**
• Finalized the Clean Power Plan and the Clean Water Rule
• Professor of the Practice of Public Health in the Department of Environmental Health at Harvard T.H. Chan School of Public Health
• Director of the Center for Climate, Health, and the Global Environmental
• Member of the Board of Directors of the Energy Foundation and Ceres
• M.Sc. in Environmental Health Engineering, Planning and Policy from Tuft’s University
Jason Sacks, M.P.H.

• Senior Epidemiologist in the Center for Public Health & Environmental Assessment within U.S. EPA’s Office of Research and Development

• **Assessment lead for the Particulate Matter Integrated Science Assessment (Draft PM ISA)**

• Key leadership roles in synthesizing the health effects evidence of air pollution for various National Ambient Air Quality Standards reviews

• International training on U.S. EPA’s Environmental Benefits Mapping and Analysis Program – Community Edition

• M.P.H. from Johns Hopkins University in 2003
Michael Kleinman, Ph.D.

• UC Irvine Professor of Environmental Toxicology
• Co-Director of the Air Pollution Health Effects Laboratory in the Department of Community and Environmental Medicine
• Adjunct Professor in College of Medicine
• Serves on the Air District Advisory Council
• Ph.D. in Environmental Health Sciences from New York University
• CA Scientific Review Panel on Toxic Air Contaminants; CA Air Quality Advisory Committee
John R. Balmes, M.D.

- Professor of Medicine at UC San Francisco
- Professor of Environmental Health Sciences in the School of Public Health at UC Berkeley
- Director of the Northern California Center for Occupational and Environmental Health
- Authored over 300 papers on occupational and environmental health-related topics

- **Physician Member of the California Air Resources Board**
H. Christopher Frey, Ph.D., F. A&WMA, F. SRA

- Glenn E. Futrell Distinguished University Professor of Environmental Engineering in the Department of Civil, Construction, and Environmental Engineering at North Carolina State University
- Adjunct professor in the Division of the Environment and Sustainability at the Hong Kong University of Science and Technology
- Fellow of the Air & Waste Management Association and of the Society for Risk Analysis
- Ph.D. in Engineering and Public Policy from Carnegie Mellon
- Former Chair/Member, EPA Clean Air Scientific Advisory Committee (CASAC)
- Former Chair/Member, 10 different CASAC NAAQS Review Panels
- Chair, Independent PM Review Panel
Lauren Zeise, Ph.D.

- **Appointed by Gov. Brown as Director of the California Office of Environmental Health Hazard Assessment in December 2016**
- Former Chief of the cancer unit at the California Department of Health Services
- Leading role in OEHHA’s development of CalEnviroScreen
- Co-led the team that developed the hazard trait regulation for California’s Safer Consumer Products program
- Member, fellow, former editor, and former councilor of the Society for Risk Analysis
- 2008 recipient of the Society’s Outstanding Risk Practitioner Award
- Ph.D. from Harvard University
Julian Marshall, Ph.D.

• Kiely Endowed Professor of Environmental Engineering at University of Washington with a focus on air quality management

• Founded and runs the Grand Challenges Impact Lab, a UW study abroad program in Bangalore, India

• Associate Editor for Environmental Health Perspectives and Development Engineering

• Published over 100 peer-reviewed journal articles

• Ph.D. in Energy and Resources from UC Berkeley
Scott Jenkins, Ph.D.

- Senior Environmental Health Scientist in EPA's Office of Air Quality Planning and Standards (OAQPS)
- Currently leading EPA’s review of the National Ambient Air Quality Standards (NAAQS) for Particulate Matter (PM)
- Howard Hughes Postdoctoral Research Fellow in the Department of Cell Biology at Duke University
- Ph.D. in Behavioral Neuroscience from the University of Alabama at Birmingham
Phil Martien, Ph.D.

• Director of the Assessment, Inventory, & Modeling Division at the Bay Area Air Quality Management District

• Leading role in the Technical Assessment of AB617’s West Oakland Community Action Plan

• Leading role in the Technical Assessment of the Air District’s 2017 Clean Air Plan: Spare the Air, Cool the Climate

• Leading role in the Air District's Community Air Risk Evaluation Program

• Ph.D. from UC Berkeley
Advisory Council Discussion with Experts

PM Health Effects Panel

PM Exposure & Risk Panel
BAAQMD’s Questions

- Are current PM standards sufficiently protective? Emphatic NO – definitely not for PM\textsubscript{2.5}.
- How has the PM health evidence been strengthened? Better “exposure” models, much larger study populations at much lower levels than before.
- What new health effects are now recognized? Strengthening of some causality determinations, but largely the focus is still premature mortality, respiratory morbidity, and cardiovascular morbidity.
- New endpoints like cancer and central nervous system effects? Opinions differ.
- New sensitive groups, like children and lower socioeconomic status, SES, populations? Growing recognition of “at risk” groups.
- Are all types of PM equal? Probably not. Or, are some more dangerous than others? Probably. But, more work needed. No components are as yet ‘exonerated.’
- How severe are PM health risks? Premature mortality is severe.
- What additional health benefits can be achieved by further reducing PM to below current standards? Difficult to quantify with certainty but on the order of tens of thousands of deaths nationally.
<table>
<thead>
<tr>
<th>Discussion Questions</th>
<th>(EXAMPLE, DO NOT CITE)</th>
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<tbody>
<tr>
<td><strong>Are current PM standards sufficiently health protective?</strong></td>
<td><strong>NOT PROTECTIVE, STANDARDS SHOULD BE LOWERED</strong></td>
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<tr>
<td><strong>Are some species of PM more dangerous than others?</strong></td>
<td><strong>QUITE POSSIBLY BUT NOT ENOUGH INFORMATION, NO PM COMPONENTS “EXONERATED”</strong></td>
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<tr>
<td><strong>What is role of ultrafine particles (UFPs)?</strong></td>
<td><strong>NOT YET CLEAR, TOX STUDIES OF CONCERN, NEED UFP FEDERAL REFERENCE METHOD, MORE MONITORING, EPI STUDIES</strong></td>
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<tr>
<td><strong>Should PM “target” expand to account for more than just mass?</strong></td>
<td><strong>IN RESEARCH ABSOLUTELY, IN REGULATION TOO SOON, UNLESS HIGHLY RISK-AVERSE</strong></td>
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<tr>
<td><strong>How should we include draft PM ISA’s new “likely-causal” health endpoints (nervous system effects, cancer) and new more sensitive populations (children, lower socio-economic status)?</strong></td>
<td><strong>NEW HEALTH EFFECTS AND GROWING RECOGNITION OF “AT RISK” GROUPS IMPORTANT (SUCH AS CHILDREN AND LOW SES), NEED TO CONSIDER</strong></td>
</tr>
<tr>
<td><strong>What are health impacts of high-concentration acute events (e.g., wildfires)? How should we compare them to day-to-day PM impacts?</strong></td>
<td><strong>NOT WELL-KNOWN SCIENTIFICALLY BUT OF CONCERN, DATA ON SUB-DAILY EXPOSURES TOO LIMITED AS YET, POTENTIALLY SERIOUS EFFECTS IN EARLY STUDIES, OTHER STUDIES ONGOING, MORE RESEARCH NEEDED</strong></td>
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Advisory Council: Initial Deliberation

Sense of the Council
• The current standards are not adequately health protective.
• Further reductions in PM will realize significant additional health benefits.
• We need more science, and we should act now.

Further Exploration
• Treating PM as an air toxic
• Expanded monitoring of UFP
• Health effects of acute PM exposures, e.g., wildfire smoke
• Identifying PM species that are particularly dangerous
• Assisting District in identifying strategies having “highest bang for buck” for health protection
• Pursuing strategies that have climate and other co-benefits
Ambient Particulate Matter (PM)

• PM is a mixture, including particles of differing origin (combustion, crustal, biological) and varying size.
• Multiple sources
Mortality – Long-term PM$_{2.5}$ Exposure

Recent evidence supports and extends the conclusions of the 2009 PM ISA that there is a causal relationship between long-term PM$_{2.5}$ exposure and mortality.

Figure 11-18. Associations between long-term PM$_{2.5}$ and total (nonaccidental) mortality in recent North American cohorts.

Note: Associations are presented per 5 µg/m$^3$ increase in pollutant concentration.

Red = recent studies; Black = studies evaluated in the 2009 PM ISA

Working Draft: Do Not Cite or Quote
Table 1-5. Summary of causality determinations for health effect categories for the draft PM ISA.

Draft PM ISA:
- 1,879 pages
- 2,647 references
The NAAQS are intended to protect both the population as a whole and those potentially at increased risk for health effects in response to exposure to criteria air pollutants.

- Are there specific populations and lifestages at increased risk of a PM-related health effect, compared to a reference population?

The ISA identified and evaluated evidence for factors that may increase the risk of PM$_{2.5}$-related health effects in a population or lifestage, classifying the evidence into four categories:

- Adequate evidence; suggestive evidence; inadequate evidence; evidence of no effect

Conclusions:

- **Adequate**: children and nonwhite populations
- **Suggestive**: pre-existing cardiovascular and respiratory disease, overweight/obese, genetic variants glutathione transferase pathways, low SES
- **Inadequate**: pre-existing diabetes, older adults, residential location, sex, diet, and physical activity

**Working Draft: Do Not Cite or Quote**
## Summary of Risk Estimates

Estimates of PM$_{2.5}$-associated deaths in the full set of 47 study areas

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Study</th>
<th>Air quality simulation approach*</th>
<th>Current Standard Absolute Risk (12/35 μg/m$^3$)</th>
<th>CS (12/35) % of baseline**</th>
<th>Alternative Standard Absolute Risk</th>
<th>Alternative Annual (10 μg/m$^3$)</th>
<th>Alternative 24-hr (30 μg/m$^3$)</th>
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<tbody>
<tr>
<td><strong>Long-term exposure related mortality</strong></td>
<td></td>
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<tr>
<td>Ischemic Heart Disease</td>
<td>Jerrett 2016</td>
<td>Pri-PM</td>
<td>16,500 (12,600-20,300)</td>
<td>14.1</td>
<td>14,400 (11,000-17,700)</td>
<td>16,400 (12,500-20,000)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>16,800 (12,800-20,500)</td>
<td>14.3</td>
<td>14,200 (10,900-17,500)</td>
<td>16,500 (12,600-20,200)</td>
<td></td>
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<tr>
<td></td>
<td>Pope 2015</td>
<td>Pri-PM</td>
<td>15,600 (11,600-19,400)</td>
<td>13.3</td>
<td>13,500 (10,100-17,000)</td>
<td>15,400 (11,500-19,200)</td>
<td></td>
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<td></td>
<td></td>
<td>Sec-PM</td>
<td>15,800 (11,800-19,600)</td>
<td>13.4</td>
<td>13,400 (9,870-16,700)</td>
<td>15,600 (11,600-19,400)</td>
<td></td>
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<tr>
<td>All-cause</td>
<td>Di 2017</td>
<td>Pri-PM</td>
<td>46,200 (45,000-47,500)</td>
<td>8.4</td>
<td>40,300 (39,200-41,400)</td>
<td>45,700 (44,500-47,000)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>46,900 (45,600-48,200)</td>
<td>8.5</td>
<td>39,700 (38,600-40,800)</td>
<td>46,200 (44,900-47,500)</td>
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<tr>
<td></td>
<td>Pope 2015</td>
<td>Pri-PM</td>
<td>51,300 (41,000-61,400)</td>
<td>7.1</td>
<td>44,700 (35,700-53,500)</td>
<td>50,700 (40,500-60,700)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>52,100 (41,600-62,300)</td>
<td>7.2</td>
<td>44,000 (35,100-52,700)</td>
<td>51,300 (41,000-61,400)</td>
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<tr>
<td></td>
<td>Thurston 2015</td>
<td>Pri-PM</td>
<td>13,500 (2,360-24,200)</td>
<td>3.2</td>
<td>11,700 (2,050-21,100)</td>
<td>13,300 (2,330-24,000)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>13,700 (2,400-24,600)</td>
<td>3.2</td>
<td>11,500 (2,010-20,700)</td>
<td>13,500 (2,360-24,200)</td>
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<tr>
<td>Lung cancer</td>
<td>Turner 2016</td>
<td>Pri-PM</td>
<td>3,890 (1,240-6,360)</td>
<td>8.9</td>
<td>3,390 (1,080-5,560)</td>
<td>3,850 (1,230-6,300)</td>
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<td></td>
<td>Sec-PM</td>
<td>3,950 (1,250-6,460)</td>
<td>9.1</td>
<td>3,330 (1,060-5,470)</td>
<td>3,890 (1,240-6,370)</td>
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<td><strong>Short-term exposure related mortality</strong></td>
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<tr>
<td>All cause</td>
<td>Baxter 2017</td>
<td>Pri-PM</td>
<td>2,490 (983-4,000)</td>
<td>0.4</td>
<td>2,160 (850-3,460)</td>
<td>2,460 (970-3,950)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>2,530 (990-4,060)</td>
<td>0.4</td>
<td>2,120 (837-3,400)</td>
<td>2,490 (982-3,990)</td>
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<td>Ito 2013</td>
<td>Pri-PM</td>
<td>1,180 (-16,237)</td>
<td>0.2</td>
<td>1,020 (-14,205)</td>
<td>1,160 (-16,234)</td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>1,200 (-16,240)</td>
<td>0.2</td>
<td>1,000 (-14,202)</td>
<td>1,180 (-16,237)</td>
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<td>Zanobetti 2014</td>
<td>Pri-PM</td>
<td>3,810 (2,530-5,080)</td>
<td>0.7</td>
<td>3,300 (2,190-4,400)</td>
<td>3,760 (2,560-5,020)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Sec-PM</td>
<td>3,870 (2,570-5,160)</td>
<td>0.7</td>
<td>3,250 (2,160-4,330)</td>
<td>3,810 (2,530-5,070)</td>
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* Pri-PM (primary PM-based modeling approach), Sec-PM (secondary PM-based modeling approach)
** CS denotes the current standard.

Current annual standard of 12 ug/m$^3$ = ~ 47 thousand deaths per year

Lower annual standard from 12 to 10 ug/m$^3$ = ~ 6-7 thousand fewer deaths per year (13-15%)
Preliminary Conclusions on the Current Primary PM$_{2.5}$ Standards

• The available scientific information can reasonably be viewed as calling into question the adequacy of the public health protection afforded by the current annual and 24-hour primary PM$_{2.5}$ standards

• Basis for this preliminary conclusion:
  – Long-standing body of health evidence, strengthened in this review, supporting relationships between PM$_{2.5}$ exposures and various outcomes, including mortality and serious morbidity effects
  – Recent U.S. and Canadian epidemiologic studies reporting positive and statistically significant health effect associations for PM$_{2.5}$ air quality likely to be allowed by the current standards
  – Analyses of pseudo-design values indicating substantial portions of study area health events/populations in locations with air quality likely to have met the current PM$_{2.5}$ standards
  – Risk assessment estimates that the current primary standards could allow thousands of PM$_{2.5}$-associated deaths per year – most at annual average PM$_{2.5}$ concentrations from 10 to 12 µg/m$^3$ (well within the range of overall mean concentrations in key epidemiologic studies)
Primary PM$_{2.5}$ Marginal Damages

Goodkind et al., PNAS, 2019
Damages and Premature Mortality

Goodkind et al., PNAS, 2019

根据图表显示，不同来源的空气污染物对健康损害和早逝人口的影响。图表中列出了多种污染物，包括PM2.5、NH3、NOx、SO2和VOC，以及它们在地面水平（Ground level）和升高（Elevated）条件下的损害和早逝人口。每个条形图的长度和颜色代表不同来源的污染物对损害和早逝的影响程度。
Regional-Scale and Community-Scale Modeling (2017)

Regional-scale modeling: covers the Bay Area

Local-scale modeling: covers West Oakland, including impacts in receptor area (white) from sources in source area (red)
Clear evidence of an association between wildfire smoke and respiratory health

- Asthma exacerbations significantly associated with higher wildfire smoke *in nearly every study*
- Exacerbations of chronic obstructive pulmonary disease (COPD) significantly associated with higher wildfire smoke in most studies
- Growing evidence of a link between wildfire smoke and respiratory infections (pneumonia, bronchitis)
Wildfire-PM$_{2.5}$ associated with heart attacks and strokes for all adults, particularly for those over 65 years old.

Increase in risk the day after exposure:
- All cardiovascular, 12%
- Heart attack, 42%
- Heart failure, 16%
- Stroke, 22%
- All respiratory causes, 18%
- Abnormal heart rhythm, 24% (on the same day as exposure)

All Cardiovascular Causes

Relative Risk

- Adults 18-44
- Adults 45-64
- Adults 65+
- All Adults

Light  Medium  Heavy

Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al. JAHA April 11, 2018
Update on Particulate Matter (PM)

Air District Work:

Regional-and Local-Scale PM$_{2.5}$ Source Apportionment

Phil Martien, PhD
Director of Assessment, Inventory, and Modeling

Advisory Council Meeting
December 9, 2019
Overview

• **Regional-scale PM$_{2.5}$ source apportionment:**
  – Informs actions to maintain attainment of PM standards
  – Reveals information gaps, as top sources are controlled

• **Local-scale PM$_{2.5}$ source apportionment:**
  – Indicates near-source exposures add to total pollution burden
  – Reveals additional information gaps
  – Suggests a regulatory gap: actions to reduce near-source exposures?
Regional Modeling: Primary and Secondary Contributions

- **Total PM$_{2.5}$**
- **Primary PM$_{2.5}$ (about 53%)**
- **Secondary PM$_{2.5}$ (about 47%)**
2016 Bay Area Emissions Summary for Key Secondary PM$_{2.5}$ Precursors

**NO$_x$**
- Area Sources 8%
- Nonroad Mobile Sources 42%
- Onroad Mobile Sources 37%
- Point Sources 13%
- Total: 91,691 tons/yr

**SO$_2$**
- Area Sources 2%
- Nonroad Mobile Sources 12%
- Onroad Mobile Sources 3%
- Point Sources 83%
- Total: 9,444 tons/yr

**NH$_3$**
- Point Sources 16%
- Area Sources 65%
- Nonroad Mobile Sources <1%
- Onroad Mobile Sources 19%
- Total: 11,582 tons/yr

**Key NO$_x$ Sources:** Diesel trucks and diesel-powered off-road equipment

**Key SO$_2$ Sources:** Petroleum refineries, manufacturing plants (cement, chemicals)

**Key NH$_3$ Sources:** Agricultural activity (livestock husbandry, fertilizer application)
PM$_{2.5}$ Bay Area Emissions Summary for Primary PM$_{2.5}$

2016 annual average PM$_{2.5}$ emissions

- Area Sources 34%
- Nonroad Mobile Sources 16%
- Onroad Mobile Sources 27%
- Permitted Stationary Sources 23%

12,392 tons/year

Bay Area Emissions Summary for Primary PM$_{2.5}$

2016 annual average PM$_{2.5}$ emissions

- Area Sources 34%
- Nonroad Mobile Sources 16%
- Onroad Mobile Sources 27%
- Permitted Stationary Sources 23%

12,392 tons/year
PM$_{2.5}$ Bay Area Emissions Summary for Primary PM$_{2.5}$

2016 annual average PM$_{2.5}$ emissions

- Residential Wood Combustion, 12%
- Other Fuel Combustion, 8%
- Commercial Cooking, 8%
- Commercial Marine Vessels, 5%
- Construction Activity, 5%
- Other Nonroad Activity, 6%
- Other Permitted Sources, 13%
- Refineries, 10%
- Vehicle Exhaust, 5%
- Brake & Tire Wear, 10%
- Road Dust, 11%
- Other Area Sources, 7%

Total emissions: 12,392 tons/year
Emissions Inventory Information Gaps

- On-road wear emissions and road dust
- Some area source categories
  - Residential wood combustion
  - Commercial cooking
PM$_{2.5}$ Bay Area Emissions

Apportionment: On-road Vehicles

PM$_{2.5}$ (tons/yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Exhaust - gas</th>
<th>Wear - gas</th>
<th>Dust - gas</th>
<th>Exhaust - diesel</th>
<th>Wear - diesel</th>
<th>Dust - diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>3,500</td>
<td>1,500</td>
<td>500</td>
<td>1,000</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>2015</td>
<td>3,000</td>
<td>1,000</td>
<td>500</td>
<td>1,500</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>2025</td>
<td>2,500</td>
<td>800</td>
<td>500</td>
<td>2,000</td>
<td>200</td>
<td>300</td>
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Vehicle Miles Travelled (VMT)

<table>
<thead>
<tr>
<th>Year</th>
<th>Billion miles/yr</th>
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<tr>
<td>2008</td>
<td>600</td>
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<tr>
<td>2015</td>
<td>600</td>
</tr>
<tr>
<td>2025</td>
<td>600</td>
</tr>
</tbody>
</table>

Data sources: EMFAC2017, California Air Resources Board 2016 State Implementation Plan Inventory
Regional-Scale and Community-Scale Modeling (2017)

Regional-scale modeling: covers the Bay Area

Local-scale modeling: covers West Oakland, including impacts in receptor area (white) from sources in source area (red)
Modeled Primary PM$_{2.5}$ (from Local Sources)*

* 30% of PM$_{2.5}$ sources, including construction, residential woodburning, and restaurants not modeled.
Local vs. Regional: West Oakland Example

PM$_{2.5}$

1.7 µg/m$^3$

Community-scale model – mapped impacts*

Regional-scale model (minus West Oakland)

*30% of PM$_{2.5}$ sources, including construction, residential woodburning, and restaurants not modeled
Unequal Impacts: PM$_{2.5}$ in West Oakland

* Contributed by modeled "present-day" emissions from existing local sources. Impacts from sources outside West Oakland not included.
Local-scale exposures: a different lens for evaluating priorities

Same concerns about on-road wear and road dust emissions estimates

We require more information about permitted sources that are not top priorities from a regional perspective
PM$_{2.5}$ Emissions (tons/yr) from Permitted Facilities

West Oakland facilities $\approx 0.5\%$
(15 tons/yr, within community boundary)

Top 5 facilities (Air District-wide) $\approx 50\%$

(All others)
Summary

• Continuing regulatory programs to reduce PM$_{2.5}$ with the current regional focus will improve health throughout the Bay Area

• As top sources are controlled, new sources become priorities and we identify new information gaps

• Local-scale assessments bring to focus the importance of some permitted sources that are a low priority from a regional perspective

• A regulatory gap: a framework that promotes PM$_{2.5}$ reductions from near-source exposures will improve health in Assembly Bill 617 communities
Update on Particulate Matter (PM) Air District Work:

Monitoring

Ranyee Chiang
Director of Meteorology & Measurements

Advisory Council Meeting
December 9, 2019
Measurements in the Bay Area
Measurements in the Bay Area (cont.)

Source Testing

Fenceline Monitoring
Measurements in the Bay Area (cont.)

Portable and Mobile Monitoring

Regional Network
Measurements in the Bay Area (cont.)

Sensor Networks
Outline: PM Monitoring

• Regional Network and Community Monitoring
  – Current capabilities
  – New developments

• What does the data show?
  – Ultrafine particles
  – Wildfire incidents

• Looking ahead
  – How could data be used
  – Options to strengthen air quality monitoring
Regional/Regulatory Network: Objectives

- Provide timely ambient air quality data to the general public
- Air quality forecasting for Spare the Air Program
- Support compliance with California and national ambient air quality standards
- Support air pollution research studies

35 Air Monitoring Stations
20 Meteorology Stations (not shown)
Monitoring Network Design Criteria

• Site Types
  – Population-oriented
  – Highest concentration of pollutants
  – Source-oriented (downwind of major pollution sources)
  – General background sites
  – Regional transport (near borders of the Air District)

• Based on population (2010 Census or estimates)
  – Number of monitoring sites in the Bay Area exceeds the required number

40 Code of Federal Regulations 58 Appendix D
Particulate Matter (PM) Measurements

Mass Measurements

- Compliance with California and National PM$_{10}$ and PM$_{2.5}$ standards
- Designate areas as attainment or nonattainment

Chemically Resolved or Speciated Data

- Support emission reduction strategies

Particle Counts

- Explore science on emissions, air quality impacts, and health effects associated with exposures
## Air District PM Instrumentation

<table>
<thead>
<tr>
<th>Analytical methods</th>
<th>PM$_{10}$ Mass</th>
<th>PM$_{2.5}$ Mass</th>
<th>PM$_{2.5}$ Speciation</th>
<th>Ultrafine Particles (PM$_{0.1}$)</th>
<th>Black Carbon Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravimetric</td>
<td>Gravimetric or Filter-based beta attenuation</td>
<td>Chemical extraction</td>
<td>Laser-based particle counter</td>
<td>Filter-based light attenuation</td>
<td></td>
</tr>
<tr>
<td>Active monitors</td>
<td>7</td>
<td>20</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

### Example photo
![Example photo](image-url)
Ultrafine PM Monitoring

Strengths:

- 7+ years of experience with deployment in diverse siting applications
- Current data can be used to understand diurnal and seasonal patterns, trends, or differences between background, near-road, and typical urban settings

Limitations:

- Cost ($60k - $100K / unit)
- Instruments in PM-burdened areas require frequent maintenance
- Difficult to assess sources and sinks
- Data may not be robust enough to link to specific health impacts
New Developments: Hyperlocal, Street-by-Street Monitoring

- Partnership with Aclima to determine differences in air quality on a highly localized scale
- Sensor-based instrumentation (NOx, CO, O3, BC, PM2.5)
- Data reported through a public portal
- Began in Richmond-San Pablo in summer 2019; entire Bay Area within two years

Use cases:
- Empower communities with information about air quality typical of where they live and work
- Identify areas having elevated background concentrations for further investigation
New Developments: Mobile Laboratory

- High accuracy, real-time instrumentation to screen for PM and air toxics at a local scale
  - PM concentration
  - Inferred particle age
  - Size-binned measurements (ultrafine through PM$_{10}$)
  - Black carbon
  - Potential to test for chemical components of PM in the future

Use cases:
- Identify and prioritize local sources of air toxics or PM
- Air quality between fixed-site monitors
- Identify locations for portable or fixed-site monitoring stations
New Developments: Portable Platforms

• High quality, battery powered, filter-based PM samplers that are relocatable
• Self-contained “suitcase” for continuous, real-time measurements using high quality, low power instruments

Use cases:
• Concentration variations throughout the day or week near an identified PM hotspot
• Measure air quality when the power is out due to high winds and fire hazard
• Verify low-cost sensor nodes
Outline: PM Monitoring

• Regional Network and Community Monitoring
  – Current capabilities
  – New developments

• What does the data show?
  – Ultrafine particles
  – Wildfire incidents

• Looking ahead
  – How could data be used
  – Options to strengthen air quality monitoring
What Do the Ultrafine Particulate (UFP) Data Show?

Levels influenced by traffic and/or photochemical reactions

- UFP highest at near-road sites
- Some sites consistently low, while others vary

Patterns of UFP throughout region differ from PM$_{2.5}$
Wildfire Smoke Dramatically Affects Bay Area PM$_{2.5}$ Levels

- 2017 and 2018 wildfire days included
- 2017 and 2018 wildfire days removed
Air District’s Strategy to Reduce Impacts from Wildfire Smoke

Communication with the public
• Issue smoke advisories and Spare the Air alerts based on air quality forecasts
• Understanding air quality measurements and data
• How to reduce exposure during smoke impacts

Grants and incentives for recovery assistance

Work with other Air Districts and Public Health Officers
• Consistent wildfire health information
• Provide guidance for schools
Outline: PM Monitoring

- Regional Network and Community Monitoring
  - Current capabilities
  - New developments
- What does the data show?
  - Ultrafine particles
  - Wildfire incidents
- Looking ahead
  - How could data be used
  - Options to strengthen air quality monitoring
## Combining Monitoring Strategies for Multiple Objectives

<table>
<thead>
<tr>
<th>Network</th>
<th>Measurements</th>
<th>Network Objectives</th>
</tr>
</thead>
</table>
| Regional Network                         | - PM$_{2.5}$ and PM$_{10}$ Mass | - Comparison with health-based standards  
- Public information  
- Track long-term trends  
- Assess out of area transport           |
| Special Projects (fixed site, portable, or mobile) | - PM size distribution  
- PM speciation  
- UFP  
- Black Carbon | - Source identification  
- Assessment of specific emission sources  
- Characterization of near-road environments |
| Sensor Networks (mobile or fixed)        | - PM Mass  
- Particle Count | - More challenging to interpret due to higher levels of uncertainty  
- Public education  
- Personal exposure  
- Identification of hot-spots  
- Comparative assessment of local air quality  
- Tracking high PM episodes |
Integrated PM Network Assessment (to be completed by July 2020)

• Evaluate PM measurement network to recommend improvements with available resources
• Address existing requirements and goals
  – Federal and state requirements
  – Understand criteria pollutant levels
• Strengthen network to address gaps
  – Incorporate multiple monitoring approaches
  – Support community air monitoring activities
  – Provide data to support other Air District activities
Update on Particulate Matter (PM) Air District Work:

Air District Grant Programs Overview

Karen Schkolnick
Strategic Incentives Division Director

Advisory Council Meeting
December 9, 2019
Overview

• Background
• Grants Overview and Priorities
  – Project Evaluation
  – Eligible Projects
• Supporting Air District Initiatives
• Results and Highlights
• Next Steps
Background

Monitoring
Planning
Regulations &
Enforcement

Education
&
Outreach

Grants
&
Loans
Grants Overview and Priorities

- Cost-effective air quality and climate protection benefits
- Accelerated adoption of cleanest commercially available technologies and investments in R&D
- Expedited emissions reductions in disproportionately impacted communities
Project Evaluation
Cost-Effectiveness (CE)

\[
CE = \frac{\text{Funds Awarded}}{\text{Tons of NOx} + \text{ROG} + (PM_{10} \times 20) \text{ reduced}}
\]

CE* estimates quantifiable, verifiable, and surplus lifetime emission reductions

*CE formula is provided by CARB Carl Moyer Program Guidelines
>$97M Awarded in 2018 to Eligible Projects

**Funding Source**
- Carl Moyer, AB 617 Community Health Protection
- Goods Movement
- Mobile Source Incentive Fund
- Transportation Fund for Clean Air
- Others*

**Project Type**
- On-road Vehicles
- Off-road Vehicles & Equipment
- Trip Reduction
- Other
- Passthrough

*Other funding sources include U.S. EPA’s DERA, California Climate Investments, & Air District’s general fund
Eligible Projects
On-road Vehicles

$32.0M On-road Vehicles

Cars & Charging Stations

Trucks

Buses
# Eligible Projects

## Off-road Vehicles & Equipment

<table>
<thead>
<tr>
<th>Category</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo Equipment</td>
<td>![Cargo Equipment Image]</td>
</tr>
<tr>
<td>Ag Equipment</td>
<td>![Ag Equipment Image]</td>
</tr>
<tr>
<td>Marine &amp; Locomotive</td>
<td>![Marine &amp; Locomotive Image]</td>
</tr>
<tr>
<td>Other Off-road</td>
<td>![Other Off-road Image]</td>
</tr>
</tbody>
</table>

**Off-road Vehicles And Equipment**

*Estimated Value: $44.4M*
Eligible Projects
Trip Reduction

Shuttles & Ridesharing
Pilot Services
Bicycle Projects

$6.2M Trip Reduction
Eligible Projects
Other & Passthrough

- Lawn & Garden
- Wood Smoke
- Climate Protection
- County Programs

$5.1M Other
$9.5M Passthrough
## Supporting Air District Initiatives

### Path to Diesel Free by ‘33

<table>
<thead>
<tr>
<th>Today</th>
<th>2023</th>
<th>2028</th>
<th>2033</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

- **Commercially Available**
- **Pre-Commercial**
- **R&D**
Supporting Air District Initiatives
Bay Area Electric Vehicle Trends & Goals

7,750 public charging ports

Over $15M invested to date

~25% of funded stations included renewables

3% of the cars are EVs

10+ EV Incentive Programs

Progress towards our EV Adoption Goals

2013: 15,000
2018: 190,000
2025: 247,000
2050: ~5 million
Supporting Air District Initiatives

Advanced Technology Demonstrations

$2.9M to deploy 11 electric trucks & haulers for commercial delivery service

$3M to deploy hydrogen-powered ferry for passenger service
Supporting Air District Initiatives
Early Emissions Reductions at Port of Oakland

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>*DPM Inventory (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Oceangoing Vessels</td>
<td>208.5</td>
</tr>
<tr>
<td>Harbor Craft</td>
<td>13.4</td>
</tr>
<tr>
<td>Cargo Handling Equipment</td>
<td>21.2</td>
</tr>
<tr>
<td>Trucks</td>
<td>15.9</td>
</tr>
<tr>
<td>Locomotives</td>
<td>2.0</td>
</tr>
<tr>
<td>Other</td>
<td>--</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>261</strong></td>
</tr>
</tbody>
</table>

>$100M in grants invested at Port of Oakland including:

- Retrofitted/replaced <1,900 drayage trucks
- Installed shorepower at 14 berths
- Replaced >1,090 on-road trucks

*Diesel Particulate Matter*
Results and Highlights

Regionwide Cumulative Emissions Reduced (tons) Since 2015

- ROG: 1,329 tons
- NOx: 3,237 tons
- PM$_{10}$: 359 tons
- CO$_2$: 576,899 tons

Highlights 2015 - 2019

- 1,000+ EV charging stations
- ~40 miles of bikeways
- 1,200+ woodstoves and fireplaces
- >100 ZE transit and school buses

53% of funds in CARE areas
Next Steps

Incentive Revenues for 2020 (in millions)

Carl Moyer, AB 617 Community Health Protection, FARMER, Goods Movement

Mobile Source Incentive Fund

Transportation Fund for Clean Air

Others*

$57.8M

$13.0M

$26.0M

$11.3M

Grant Programs

$108M Total

* Others include Clean Cars for All and Climate Tech Finance (loan guarantee)
Next Steps

New & Expanded Grant Programs

• Secure new sources of funding
• Expand eligibility and initiate new programs
  – Expediting public health benefits in disproportionately impacted areas
  – Prioritizing programs that provide co-benefits
Particulate Matter Exposure
CARB Health Research and Rule

Álvaro Alvarado
California Air Resources Board
December 9, 2019
PM Exposure is an Important Public Health Concern

• Why are we concerned about PM?
  • Lots of evidence for health impacts

• If PM2.5 ↓ to background levels, could prevent (annually) about:
  • 7,200 premature deaths
  • 1,900 hospitalizations
  • 5,200 emergency room visits
But That’s Not All – Additional Evidence of PM’s Negative Health Impacts

• Strong evidence for increased:
  • Asthma attacks
  • Respiratory symptoms
• Probable association with:
  • Work loss days
  • Restricted activity days
  • Adverse brain effects
PM2.5 Trend in the San Francisco Bay Area Air Basin

- 1993 Cleaner Diesel Fuel
- 2001 Truck Engine Standards
- 2011 Truck & Bus Regulation

NAAQS = 12 µg/m³

Estimated from PM10
CARB’s Current Efforts and New Challenges
Wildfire-related PM Exposures

• Millions of Californians exposed to wildfires in 2018
• Wildfires: more frequent & intense with climate change
• Little known about health impacts
  • PM emitted during fire; post-fire ash
  • More structure/vehicle fires
• Particular concern: children & elderly

Forecast Average Annual Area Burned

Source: CalAdapt.org
CARB Research: Wildfire Health Impacts in Rhesus Macaques

- Infant monkeys in outside enclosures unintentionally exposed to wildfire smoke (Miller, UC Davis)
- As adolescents & young adults:
  - Impaired immune function
  - Changes in lung structure
  - Reduced lung function
  - Changes passed to next generation

© CNPRC, UC Davis
CARB Research, in progress: Wildfire Emissions

- Understanding and mitigating wildfire risks (Goldstein, UC Berkeley)
  - Mobile measurements (in-house research with UC Berkeley & UC Riverside)
- NASA aircraft: investigating wildfire emissions & downwind air quality (Blake, UC Irvine)
PM from Brake & Tire Wear

• Successful reduction of regional PM from vehicle exhaust
• Vehicle tailpipe emissions most important regionally
• Non-tailpipe emissions may have localized importance
• Uncertainties in emissions & health impacts
CARB Research, in progress: Brake & Tire Wear

• Quantifying brake & tire wear emissions (Kishan, Eastern Research Group)

• Examining real-world brake & tire emissions and exposure to downwind communities (Jung, UC Riverside)

• In-house laboratory research projects

• Understanding potential health impacts (Jerrett, UCLA)
Health Risk from Ultrafine PM (UFPM)

• Potential exposure risks:
  • High numbers & chemicals attach to surface
  • Once inhaled, can go deep into lung
  • Can enter bloodstream, travel to organs
  • UFPM highly variable (space & time)
  • Sparse historical data
CARB Research: Health Effects of UFPM

• Monitoring, modeling, and health impacts of UFPM (Kleeman, UC Davis)
• Preliminary results suggest increased risk of premature death with higher exposure
CARB Research, in progress: Short-term PM Exposure

• White paper: reviewing short-term PM exposure impacts (Kleinman, UC Irvine; in progress)

• Air monitoring in AB 617 communities
  • Localized pollutant exposures

• Determine if need to address short-term exposures
Statewide Mobile Source Strategies Overview

- Heavy Duty Trucks
- Warehouses
- Passenger Cars
- Trains
Heavy Duty Trucks

• Advanced Clean Trucks regulation
• Heavy-duty vehicle inspection and maintenance
• Innovative Clean Transport
• Airport Shuttles
• Low NOx Omnibus Rule
Warehouses

- Freight Handbook
- Transport refrigeration unit regulations
- Drayage truck regulation amendments
- Cargo handling equipment amendment
Passenger Cars

• Advanced Clean Cars 2
• Catalytic converter theft reduction
Trains

• Reduce idling for all rail yard sources
• Potential development of regulation to reduce emissions for locomotives
Thank you
Update on Particulate Matter (PM) Air District Work:

PM Rules and Regulatory Development

Victor Douglas
Rule Development Manager

Advisory Council Meeting
December 9, 2019
Overview

• Approaches to Regulate PM
• PM Rules and Regulations
• Current and Future Efforts
  – Regional attainment
  – Localized impacts
  – Gap analysis
Three Ways to Regulate PM:

1. Originally regulated as a Nuisance
   - Open burning (original Reg 1)
   - Dust and aerosol (original Reg 2)

2. Criteria (i.e., regional)

3. Toxic (i.e., local/community level)
   - Diesel PM
Regional Approach

• Attainment of ambient air quality standards
• Control of Primary PM
  – Filterable
  – Condensable
• Control of Secondary PM
  – Oxides of Nitrogen (NOx)
  – Sulfur Dioxide (SO₂)
PM Rules & Regulations

- Regulation 2: Permits
- Regulation 5: Open Burning
- Regulation 6: Particulate Matter
- Regulation 9: Inorganic Gaseous Pollutants
- Regulation 11: Hazardous Pollutants
- Regulation 12: Miscellaneous Standards of Performance
PM Rulemaking Efforts

• 2012 – **Rule 2-2 amendments** to add New Source Review permitting requirements for PM$_{2.5}$
• 2012 – **New Rule 9-13** to reduce PM emissions from Portland cement kilns
• 2013 – **New Rule 6-4** and **new Rule 12-13** to reduce PM emissions from metal foundries and shredding facilities
PM Rulemaking Efforts

• 2015 – Rule 6-3 amendments to further reduce wood smoke from wood-burning devices
• 2016 – New Rule 9-14 to reduce precursors of secondary PM from petroleum coke calcining operations
• 2018 – New Regulation 6, new Rule 6-6, and Rule 6-1 amendments to reduce PM emissions from fugitive dust sources
• 2019 – Rule 6-3 to extend No Burn Days for the Wildfire Response Program
2018 PM Rules

• New Regulation 6 for common definitions and test methods
• New Rule 6-6 for prohibition of trackout
• Rule 6-1 amendments for general requirements and bulk material handling
• Reduce PM emissions from fugitive dust sources
• Expected emission reductions of 1.6 tpd PM$_{10}$, 0.2 tpd PM$_{2.5}$
Current and Future Efforts

• Continued **regional** efforts on further PM reductions (e.g., Rule 6-5: PM from FCCUs)
• Source categories and rule efforts identified in planning efforts
• Additional areas from gap analysis
  – Restaurants
  – Wood smoke
  – Indirect and magnet sources
  – PM as a toxic pollutant
Current and Future Efforts (cont.)

• To address localized PM issues
• Regulatory framework for site-specific localized PM impacts
• Existing localized approaches for toxics
  – Air District Rule 11-18 for Air Toxic Emissions from Existing Facilities
  – AB 2588 Air Toxic Hot Spots Program
Discussion

Questions?
Discussion Questions

Are current PM standards sufficiently health protective?

Are some species of PM more dangerous than others?

What is role of ultrafine particles (UFPs)?

Should form of target expand to account for more than just mass?

How should we include draft PM ISA’s new “likely-causal” health endpoints (nervous system effects, cancer) and new more sensitive populations (children, lower socio-economic status)?

What are health impacts of high-concentration acute events (e.g., wildfires)? How should we compare them to day-to-day PM impacts?
Discussion Questions

What are major sources of PM in the Bay Area?

What PM levels exist in Bay Area? What health risks do they pose?

How much additional health benefit can be achieved?

How should we account for spatial scale of effects (i.e., regional versus local-scale impacts, including proximity to major sources)?

How should we determine which measures would most move public health needle?
Deliberation Questions

What is bullseye in clean air target? How clean is clean enough?

How will we know when we get to target? What metrics should we use to track progress?

How do we combine criteria pollutants and toxics? Cancer and non-cancer health endpoints? Short- and long-term effects?

How can we make sure everyone is treated fairly?

How can we ensure that everyone breathes clean air?

What are most important actions that can be taken now? And, in future?
Discussion Questions (DRAFT)

Are current PM standards sufficiently health protective?

NOT SUFFICIENTLY PROTECTIVE; MORE STRINGENT STANDARDS NEEDED

Are some species of PM more dangerous than others?

QUITE POSSIBLY BUT NOT ENOUGH INFORMATION; NO PM COMPONENTS “EXONERATED” THOUGH

What is role of ultrafine particles (UFPs)?

NOT YET CLEAR, BUT TOX STUDIES OF CONCERN; NEED UFP FEDERAL REFERENCE METHOD; MORE MONITORING; EPI STUDIES NEEDED

Should PM “target” expand to account for more than just mass?

IN RESEARCH, ABSOLUTELY; IN REGULATION, TOO SOON, UNLESS HIGHLY RISK-AVERSE

How should we include draft PM ISA’s new “likely-causal” health endpoints (nervous system effects, cancer) and new more sensitive populations (children, lower socio-economic status)?

STRONGER EVIDENCE, NEW HEALTH EFFECTS; GROWING RECOGNITION OF “AT RISK” GROUPS (E.G., CHILDREN AND LOW SES); NEED TO CONSIDER

What are health impacts of high-concentration acute events (e.g., wildfires)? How should we compare them to day-to-day PM impacts?

NOT WELL-KNOWN SCIENTIFICALLY, BUT OF CONCERN; DATA ON SUB-DAILY EXPOSURES TOO LIMITED AS YET; POTENTIALL SERIOUS EFFECTS REPORTED IN EARLY STUDIES; NEW STUDIES ONGOING; MORE RESEARCH NEEDED
<table>
<thead>
<tr>
<th>Discussion Questions (DRAFT)</th>
</tr>
</thead>
</table>

What are major sources of PM in the Bay Area?

**WEST OAKLAND:** PM$_2.5$, TOP 3 – PORT (17%), STREET (17%), HIGHWAY (16%); Diesel PM, TOP 3 – PORT (57%), STREET (7%), HIGHWAY (8%)

---

What PM levels exist in Bay Area? What health risks do they pose?

**WEST OAKLAND:** PM$_2.5$ = 8.7 ug/m³ (ALL SOURCES, AVERAGE), LOCAL SOURCES = 1.5 to 2.2 ug/m³ (BY NEIGHBORHOOD); Diesel PM = 0.7 ug/m³ (AVERAGE); HYPER-LOCAL HOT SPOTS COULD BE HIGHER

---

How much additional health benefit can be achieved?

REDUCING ANNUAL PM$_2.5$ FROM 12 ug/m³ TO 10 ug/m³ COULD REDUCE RISK BY 10-15%; THOUSANDS FEWER DEATHS IN U.S. EACH YEAR

---

How should we account for spatial scale of effects (i.e., regional versus local-scale impacts, including proximity to major sources)?

**SPATIAL SCALE IMPORTANT; REGIONAL- VS. LOCAL- VS. HYPER-LOCAL-SCALE IMPACTS**

**WEST OAKLAND:** PM$_2.5$ CONCENTRATION – OVERALL, 80% FROM REGIONAL SOURCES, 20% FROM LOCAL SOURCES; Diesel PM CONCENTRATION – OVERALL, 40% FROM REGIONAL SOURCES, 60% FROM LOCAL SOURCES; HYPER-LOCALIZED HOT SPOTS COULD BE HIGHER

---

How should we determine which measures would most move public health needle?

**NEED MORE SCIENCE, AND NEED TO ACT NOW; OPTIONS TO BE DETERMINED; DISTRICT STAFF TO IDENTIFY**
Deliberation Questions *(DRAFT)*

What is bullseye in clean air target? How clean is clean enough?

How will we know when we get to target? What metrics should we use to track progress?

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