UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

December 7, 2022

MEMORANDUM

SUBJECT: Scientific Advisory Board (SAB) Review of the Technical Support Documents for Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits and BenMAP Software Tool

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TO: Holly Stallworth, Ph.D.
Designated Federal Officer
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This memo transmits all materials needed for the SAB review of the Technical Support Documents for Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits and the Environmental Benefits and Mapping (BenMAP) Software Tool.

With respect to BenMAP, the U.S. Environmental Protection Agency (U.S. EPA) currently uses the desktop BenMAP-CE tool to calculate and monetize the health benefits or disbenefits from air quality changes. The newly developed web version of BenMAP implements the same calculations but will support a variety of improvements to Agency processes.

The web tool is available at the URL https://benmap.epa.gov for access by the SAB Panel. Its user manual, entitled *User's Manual*, is available for download from the BenMAP website at https://www.epa.gov/benmap/benmap-manual-and-supporting-documentation. The *User's Manual* provides a quick start guide as well as detailed instructions on how to use the tool.

The Technical Support Document *Estimating PM2.5- and Ozone-Attributable Health Benefits* was prepared by the U.S. Environmental Protection Agency (U.S. EPA) in 2021. The 2021 Technical Support Document was used to support the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS. This document describes the process by which the Agency reviews health and economic studies in deciding how to estimate and monetize the health effects of air quality changes, the data that are used for these calculations, and how the Agency characterizes uncertainty in these calculations and evaluates their sensitivity to certain alternate assumptions. An update to the 2021 Technical Support Document will be released soon and made available to the public.

We also include spreadsheets which list and describe the studies used in BenMAP, based on the criteria described in the Technical Support Documents. These are available for download from https://www.epa.gov/benmap/benmap-manual-and-supporting-documentation.

Below are our charge questions on both BenMAP and the Technical Support Document. We look forward to discussing these topics at our upcoming meetings. Should you have any questions regarding the review documents, please contact me (919-541-3889; email sasser.erika@epa.gov) or my staff Dr. Peter Maniloff (919-541-5548; email maniloff.peter@epa.gov) or Mr. Neal Fann (919-541-0209; email fann.neal@epa.gov).

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Attachments: Background and charge questions for the SAB review of the BenMAP, the Technical Support Document *Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits*, the excel file HIF_studies.xlsx, and the *User's Manual*

Draft Charge Questions for the SAB Review of BenMAP and the Technical Support Document *Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits*

Background

Consistent with Executive Order 12866[1], the U.S. Environmental Protection Agency (EPA) quantifies the estimated number and economic value of avoided air pollution-related premature deaths and illnesses associated with its proposed and final regulations. The methods used are designed to be in accordance with EPA's Guidelines for Preparing Economic Analyses[2] and OMB Circular A-4,[3][4] This analysis which is part of the Regulatory Impact Analyses (RIA), reflects previous advice received from both the National Academies of Sciences and the EPA Science Advisory Board (NRC, 2002, 2008; U.S. EPA Science Advisory Board, 2004, 2010).

The estimated dollar value of the effects attributable to fine particles (particles with aerodynamic diameters ≤ 2.5 μm, hereafter "$PM_{2.5}$") and ground-level ozone (hereafter "ozone") are substantial and account for the preponderance of monetized benefits of all regulations promulgated by the U.S. Government. [5] The magnitude of those benefits is driven by the estimates of avoided premature mortality associated with lowering PM2.5 and ozone levels. The EPA's approach for monetizing premature mortality estimates is shaped by science as well as science policy considerations. The two of the biggest drivers here are the longstanding approach to monetizing premature mortality (i.e., the research and assumptions underlying the "value of a statistical life" calculation) and to the long-standing practice of quantifying benefits associated with all reductions in ambient air concentrations for $PM_{2.5}$ and ozone.

This Review

The current peer review panel covers two separate, but related topics:

(1) EPA's approach to identifying, selecting and parameterizing endpoints to quantify and monetize, as outlined;
(2) EPA's implementation of calculating those effects using the BenMAP tool. BenMAP is a software tool which implements the calculations based upon the decisions made in (1)).

For the first topic, the SAB panel is asked to evaluate the approach EPA took for selecting human health endpoints to quantify, risk estimates from epidemiologic studies, and economic unit values to monetize effects, as well as the approach for characterizing the associated

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[1] https://www.archives.gov/files/federal-register/executive-orders/pdf/12866.pdf
[2] https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses
[3] https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf
[4] White House memorandum Modernizing Regulatory Review, January 20,2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/modernizing-regulatory-review/, may eventually have implications for EPA's Guidelines.
[5] In some years (most recently 2017), the OMB Report to Congress on the Benefits and Cost of Regulations provides estimates of the benefits and costs of federal regulations by Agency and Program Office. https://www.whitehouse.gov/omb/information-regulatory-affairs/reports/

uncertainties.

For the second topic, the panel will review the new cloud-based version of the BenMAP software—specifically, how the program implements EPA's methods for quantifying estimated benefits, focusing in particular on the user interface and software engineering.

Description of the Technical Support Document

As the evidence for $PM_{2.5}$ and ozone-related adverse effects continues to evolve, the agency updates its methods; this can include updating key input parameters, such as the concentration-response parameters used to quantify counts of adverse effects, the unit values used to estimate the dollar value of these effects, or the baseline rates of death or disease used to calculate the incidence of premature death and illnesses. EPA usually updates its methods when the agency assesses whether the National Ambient Air Quality Standards (NAAQS) for these two pollutants are adequate to protect public health. EPA publishes an Integrated Science Assessment (ISA) as part of the NAAQS review process, which assesses the causal nature of relationships between air pollutants and health effects by evaluating the epidemiologic, clinical and toxicological evidence for each pollutant. EPA uses this document to inform certain aspects of the benefits analyses design.

The latest PM ISA was completed in December 2019; the latest ozone ISA was completed in April 2020. In March 2021, EPA developed a TSD entitled *Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits* (link), which it published to support the 2021 Final Revised CSAPR Update for the 2008 Ozone Season NAAQS rulemaking RIA.[6] This TSD was updated in August 2022 (link) based on an update to the ISA and the RIA associated with the regulatory proposal to change the current NAAQS for particulate matter. Both the 2021 TSD and the 2022 update should be reviewed in answering the charge questions below.

When developing the 2021 TSD and 2022 update, EPA aimed to clearly articulate a science-based rationale for selecting human health endpoints to quantify and risk estimates to use and monetize in an air pollution benefits assessment. To that end, the TSD sought to:

- Establish transparent and defensible criteria for identifying epidemiologic studies and risk estimates most appropriate to inform a $PM_{2.5}$ and ozone benefit analysis for an RIA (section 2.1),
- Identify pollutant-attributable health effects for which the ISA[7] reports strong evidence (i.e., causal relationship or likely to be causal relationship) and that may be quantified in a benefits assessment (section 2.2),
- Collect baseline incidence and prevalence estimates (section 3) and demographic information (section 4),

[6] Although EPA has historically disseminated its updated methods in the Regulatory Impact Analysis accompanying each proposed and promulgated NAAQS, because the NAAQS for both PM and ozone remained unchanged in 2020, EPA instead published this TSD to share its updated benefits analysis methods.
[7] https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534#tab-3

- Develop new, or update existing, economic unit values (section 5), and
- Characterize uncertainty associated with quantified benefits estimates (section 6).

EPA anticipates further updating the TSD based on the comments in the current peer review, and as new evidence related to the above bullets becomes available, thereby informing future RIAs.

Charge Questions for the first topic

Questions 1-5 are related to the first goal of the panel (EPA's approach to identifying, selecting and parameterizing endpoints to quantify and value). To support the Panels' review, EPA is providing documentation in the form of the TSD which describes EPA's approach.

1. Sections 1 and 2 of the TSD describe EPA's approach to identifying (a) health endpoints to quantify; (b) the epidemiologic studies from which we draw inferences about associations between historical changes in air quality and; (c) unit changes in risk estimated by the chosen epidemiologic studies. Please consider these sections in answering questions 1(a)-1(c).

    a. Is this approach appropriate for developing a set of health endpoints, epidemiologic studies, and risk estimates for use in generating the estimated benefits associated with regulatory changes in emissions as part of the Regulatory Impact Analyses? Please explain. Please comment on the strengths and weaknesses of the approach.

    b. The TSD describes the "minimum" and "preferred" criteria used to select epidemiologic studies and subsequent risk estimates that should be used to develop Health Impact Functions for inclusion in a benefits analysis. Please comment on whether the minimum and preferred criteria identified by EPA are appropriate, on the strengths and weaknesses of the preferred criteria identified by EPA, and whether the application of these criteria has been implemented with consistency in the TSD. Do you recommend adding to or editing the criteria for the selection of studies and risk estimates, or does the SAB have recommendations for alternative criteria or changes to EPA's approach to applying those criteria? (See Section 2.2.3 and selection Excel file for the list of studies included)? Please explain.

    c. Considering existing OMB and EPA guidance on preparing economic analyses, please comment on: (1) the conditions under which the science or other best practice guidelines would support EPA presenting multiple estimates of pollutant-attributable mortality; (2) whether the mortality estimates described in the TSD capture the range of potential benefits of $PM_{2.5}$ and ozone reduction; and (3) the scientific and analytic advantages and disadvantages of reporting benefits calculated using a pooled risk estimate versus reporting benefits calculated using the single estimate best characterizing risk.

    d. Currently, EPA updates its selection of health studies approximately every five years, in concert with each new ISA. What is the appropriate frequency for EPA to update its selection of health studies? What would be too frequent? What would be insufficiently frequent?

2. Sections 3 and 6.3 of the TSD describe the baseline rates of death and disease used to quantify counts of pollutant-attributable effects. Please consider the approaches used to generate these baselines as you answer questions 2(a)-2(e).

    a. Are these rates appropriately matched to each outcome according to ICD-9 or ICD-10 code?

    b. Are these rates resolved to the appropriate spatial and temporal scale for performing benefits analyses?

    c. Are the assumptions EPA makes in projecting death rates reasonable?

    d. Is the approach used to estimate race- and ethnicity-stratified mortality incidence appropriate?

    e. Should EPA also consider projecting all or some morbidity rates?

3. Section 4 describes the population and demographic data used for quantifying health effects. Please reference this section in answering questions 3(a)-3(d).

    a. Does the demographic information used to quantify pollutant-attributable cases as described in Section 4 reflect the best available science?

    b. The Woods & Poole projected population is used to quantify and value $PM_{2.5}$ and ozone health impacts. Is the Woods & Poole data appropriate for this purpose? Are there alternative projections that EPA should consider using instead? Why might your proposed alterative be preferable?

    c. Are the age, sex, race and ethnicity strata in the population data used to quantify effects appropriately delineated and appropriate for quantifying effects across subpopulations?

    d. Are the data used to estimate the number of individuals according to poverty status, educational attainment, and linguistic isolation appropriate?

    e. Are there other characteristics across which EPA should report stratified results? If so, what characteristics, and what would be appropriate ways to measure those characteristics?

4. Sections 5 and 6.4 describe the approaches EPA uses for valuing effects. Please reference this section in answering questions 4(a)-4(j).

    a. EPA currently uses a "20-year segmented lag" when discounting the value of $PM_{2.5}$ and ozone-related deaths associated with long-term exposure, consistent with SAB advice received in 2004. EPA believes that a lag of five years or less as the primary method of analysis for $PM_{2.5}$ and as a sensitivity analysis for ozone is more appropriate in light of the current best available scientific evidence. Please comment on whether EPA's conclusion reflects the current state of the science and whether an alternative lag structure associated with long-term exposure should be assumed.

b. Please comment on the approach to estimating neurological health effects using a cost of illness measure for hospital visits, as well as whether it is appropriate to assume that the first hospital visit indicates disease onset.

c. EPA currently values lung cancer using an estimated latency period between air pollution exposure and disease onset. Do you have any suggestions for improving the approach used?

d. EPA currently values acute myocardial infarctions (AMI) using a cost of illness measure. The cost of illness varies by age. Do you have any suggestions for improving the approach used?

e. EPA uses morbidity cost of illness (COI) approaches for allergic rhinitis, asthma symptoms (albuterol use), cardiac arrest, school loss days, stroke, and work loss days. Do you have any suggestions for improving the approach used?

f. Do have suggestions for improving the other morbidity willingness to pay (WTP) approaches: asthma symptoms (cough, wheeze, chest tightness, and shortness of breath) and minor restricted activity days (MRADs).

g. Should EPA consider other morbidity or economic impacts of $PM_{2.5}$ and ozone pollution, including but not limited to labor productivity and human capital formation? Which ones should be considered and under what conditions or in what settings they should be considered?

h. In some cases, EPA may determine that the evidence of a relationship between PM or ozone and a health endpoint indicates that the relationship causal or likely causal, but be unable to confidently value that endpoint (e.g., metabolic effects of short-term ozone exposures, for which the 2020 Ozone ISA made a "likely to be causal" determination). Can SAB recommend methods (e.g., bounding approaches) to better characterize presently unquantifiable health benefits for endpoints for which there is sufficient evidence of pollutant-attributable health effects?

i. In some cases, EPA may determine that the evidence of a relationship between PM or ozone and a health endpoint is insufficient to indicate that the relationship is causal or likely causal. Section 1 describes a conceptual perspective on valuing health outcomes under causal uncertainty in the relationship between exposure and those outcomes. Are there scientific studies or practical settings where analysts accounted for causal uncertainty when estimating WTP estimates to reduce mortality or morbidity risks? Please comment on the appropriateness and potential for estimating and applying WTP estimates to avoided mortality or morbidity risks when there is causal uncertainty. An example is ozone-attributable all-cause mortality, which is discussed in section 6.2.3 of the TSD and not currently valued.

j. Please comment on the income adjustment factors that EPA uses to value endpoints (section 5.4).

5. Section 6.4 and 6.5 describe approaches EPA uses for characterizing uncertainty. Please reference these sections in answering 6(a)-6(d).

a. EPA uses risk estimates from air pollution epidemiologic studies when quantifying the number of avoided cases of premature death and illness from future changes in air quality. Given that, by design, epidemiologic studies report associations between historical changes in air quality and the odds (or relative risk, or hazard ratio) of an outcome, how should EPA characterize this source of uncertainty? Are there methods to estimate the magnitude of this uncertainty that EPA should explore using? Please explain.

b. EPA performs a Monte Carlo simulation to quantify a distribution around certain input parameters including the beta coefficient used to quantify attributable cases of air pollution-related effects. Are there other input parameters for which EPA should specify a distribution? To the extent that insufficient data exist to specify such a distribution, should EPA assume a distribution? What other methods are available to quantitatively or qualitatively assess uncertainty if sufficient data are lacking?

c. Does this section sufficiently characterize the various sources of uncertainty associated with the estimate of WTP for reduced PM2.5 and ozone exposure? Are there other sources of uncertainty that warrant identification and evaluation?

d. Please comment on whether and how EPA could account for uncertainties associated with the shape of the concentration-response function, particularly at concentrations near and below the lowest concentrations observed in the epidemiologic studies used to quantify health benefits.

e. Please comment on any other assumptions that significantly impact the magnitude of the benefits for which EPA should generate more explicit assessments of uncertainty, either quantitative or qualitative.

Charge Questions for Second Topic

Questions 6-10 are related to the second goal of the panel (how the program implements EPA's methods to quantify estimated benefits, focusing on the user interface and software engineering), in the context of the recently developed cloud-based implementation of BenMAP. BenMAP is a complex tool incorporating air quality modeling results, demographic and population data and projections, economic valuation estimates, health related concentration response functions, and numerical methods and parameterization. To support the Panel's review of BenMAP, EPA is providing a document entitled "User's Manual" (link) as well as providing panel members access to the cloud-based version of the tool and training on how to use the tool.

6. BenMAP uses a broad set of air quality (monitoring and modeling), demographic, economic, concentration-response, incidence, and prevalence data.

   a. Are the contents and sources of data input data transparent and appropriate?

   b. Are the inputs appropriately indicated for user selection and implemented as documented in the referenced literature?

c. Is the information provided to judge the sources and quality of the underlying data used for calculation or as input to algorithms and parameterizations sufficient?

d. Are the concentration-response functions appropriately implemented, documented, and referenced for users to evaluate and select? Are the concentration-response functions appropriately included or indicated in outputs?

e. Has EPA appropriately characterized the capabilities and limitations of the BenMAP tool and supporting appendices with respect to incorporating externally created air quality modeling data inputs (3.3.1) and estimated changes in air quality over time? Are there tools that EPA might consider offering to improve information quality for air quality monitoring data inputs?

For reference, the document "User's Manual" (link) describes the inputs [Chapters 2,3,5], underlying data [Chapter 11, Appendix I], concentration-response functions [Appendices B, D, E, F], and economic valuation parameters [Appendices G, H].

7. Please comment on the technical implementation and transparency of the tool's calculations and presentation of output results. Please include discussion on the extent to which:

   a. results are correctly calculated, given the technical descriptions;

   b. documentation clearly describes how results are calculated;

   c. results are presented clearly and with adequate explanation;

   d. results are useful and appropriate for the intended scientific or policy purposes as documented; and

   e. potential biases or uncertainties have been appropriately indicated and appropriate user notices are made available for practitioners applying the tool to their scientific or policy analyses.

   For reference, the attached document "User Manual for BenMAP" describes the presentation of results [Chapter 10].

8. In answering questions 8(a)-d(d), please consider the user interface, software platform and implementation, data formats, documentation and the user experience of the BenMAP software. Do these elements support the user's ability to:

   a. make appropriate analytic choices;

   b. conduct a novel analysis;

   c. revisit a prior analysis to either replicate it or edit and rerun the prior analysis; and

   d. appropriately interpret and present results?

9. Please comment on what types of changes the SAB believes warrant subsequent peer review of the BenMAP software.

10. Please discuss any emerging trends in software development, computer science, or data management technologies that should be considered or prioritized, for future upgrades to the BenMAP software or similar tools