

Science Advisory Board (SAB) Draft Report (5/5/16) to Assist Meeting Deliberations – Do not Cite or Quote.

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5 EPA-SAB-16-xxx

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7 The Honorable Gina McCarthy
8 Administrator
9 U.S. Environmental Protection Agency
10 1200 Pennsylvania Avenue, N.W.
11 Washington, D.C. 20460

12
13 Subject: SAB Review of EPA’s Proposed Methodology for Updating Mortality Risk
14 Valuation Estimates for Policy Analysis
15
16

17 Dear Administrator McCarthy:
18

19 The EPA’s National Center for Environmental Economics (NCEE) requested advice from the Science
20 Advisory Board (SAB) on proposed improvements in the agency’s methodology for estimating the value
21 of mortality risk reductions, also known as the value of statistical life (VSL). The EPA requested that the
22 SAB review three documents: (1) a white paper titled *Valuing Mortality Risk for Policy: a Meta-
23 Analytic Approach* (“White Paper”); (2) a report titled *The Effect of Income on the Value of Mortality
24 and Morbidity Risk Reductions*; and (3) a technical memorandum titled *Recommended Income Elasticity
25 and Income Growth Estimates: Technical Memorandum*. The White Paper was developed to describe
26 the EPA’s proposed approach for estimating values for reductions in mortality risk for use in benefit-
27 cost analysis. The other documents discuss options for updating the agency’s recommended estimate for
28 the income elasticity of the VSL.
29

30 In response to the EPA’s request, the SAB Environmental Economics Advisory Committee was
31 convened to review the White Paper and other documents. The SAB was asked to respond to 19 charge
32 questions that focused on: (1) whether the methods used to select data for the analysis were appropriate
33 and scientifically sound; (2) whether relevant studies were adequately included in the analysis; (3)
34 whether the methodology used to analyze the data was scientifically sound; (4) whether the EPA’s VSL
35 estimates represented scientifically sound conclusions; (5) the development of a protocol for future
36 updates of the VSL; and (6) whether the EPA’s approach for estimating the income elasticity of VSL
37 was appropriate and scientifically sound. The enclosed report provides the SAB’s consensus advice and
38 recommendations.
39

40 In general, the SAB finds that the meta-analytic methods used in the White Paper to develop VSL
41 estimates for the U.S. population appear to be scientifically sound and consistent with standard and
42 accepted practices. However, more detailed information should be provided in the White Paper to
43 explain and justify use of the methods, discuss how standard and accepted practices have been applied,
44 and strengthen the analysis. The SAB also recommends that the agency consider using a variation of the
45 non-parametric method that incorporates information on sampling error variance from each study to
46 develop estimates of the VSL. The SAB’s major comments and recommendations are provided below.

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- 1
- 2 • The evidence of study validity considered by the EPA in developing the dataset for the analysis is
- 3 appropriate but incomplete. To strengthen the assessment, the EPA should consider applying
- 4 additional tests of validity and also clarify how evidence of validity was applied to all of the studies
- 5 considered for use in the analysis.
- 6
- 7 • The SAB recommends that in the future, the EPA broaden the scope of studies used to derive values
- 8 for reducing both mortality and morbidity risks. There are a significant number of published studies
- 9 that estimate willingness to pay for improved health and reduced health risks, and a literature on
- 10 benefit-risk and risk-risk tradeoff preferences in health and health care that could enrich the evidence
- 11 on risk preferences and provide support for benefits-transfer applications.
- 12
- 13 • There has been a lack of significant growth in the VSL literature since the last consideration of this
- 14 topic by the SAB in 2011. The SAB provides citations for additional studies that could be included
- 15 in the White Paper. However, the SAB also recommends that the agency consider commissioning
- 16 more studies or creating other incentives for new studies to improve the prospect for a deeper
- 17 literature to support future reviews of VSL.
- 18
- 19 • Some VSL estimates in the White Paper were constructed by weighting subpopulation estimates to
- 20 approximate an estimate for the general population. Given the limited VSL literature, the SAB
- 21 recognizes the need to develop a weighting approach for subpopulation estimates. However,
- 22 additional information is needed in the White Paper to explain how the weighting was actually done
- 23 and how the studies were brought together for the aggregate estimate.
- 24
- 25 • The White Paper should provide detailed information about how the standard error of the VSL is
- 26 calculated when the original studies do not report it. A detailed description of the method, including
- 27 the formula used in the calculation for each study, should be provided in the White Paper.
- 28
- 29 • The White Paper classifies estimates into independent samples called groups. The SAB supports
- 30 grouping the studies in the White Paper based on similar samples to account for the lack of
- 31 independence in estimates constructed from the samples. However, additional detail should be
- 32 provided to clarify how the grouping decisions were made and an analysis should be conducted to
- 33 check the robustness of the results to different plausible group definitions.
- 34
- 35 • The SAB finds that a five year interval for updating VSL estimates is appropriate, but there is a need
- 36 to increase the pool of high quality studies to support the VSL meta-analysis. The EPA should
- 37 consider whether estimation of VSL and its various attributes should be a high priority topic for
- 38 grants and fellowships, sponsored conferences, and special issues of journals. There should be a
- 39 single set of criteria for determining which studies are of sufficient quality to be included in current
- 40 and future estimates of VSL.
- 41
- 42 • The EPA report and technical memorandum on the income elasticity of VSL provide reasonable
- 43 summaries of the income elasticity literature. However, the summary of the literature indicates that
- 44 there is not an adequate informational basis for deriving a consensus estimate of the income
- 45 elasticity of VSL. Therefore the SAB recommends that the EPA consider using the preferred VSL

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1 model specification to compare VSL estimates at different points in time and use that to obtain the
2 implied income elasticity of VSL.

3

4 The SAB appreciates the opportunity to provide the EPA with advice on this important subject. We look
5 forward to receiving the agency's response.

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Sincerely,

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NOTICE

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4 This report has been written as part of the activities of the EPA Science Advisory Board (SAB), a public
5 advisory group providing extramural scientific information and advice to the Administrator and other
6 officials of the Environmental Protection Agency. The SAB is structured to provide balanced, expert
7 assessment of scientific matters related to problems facing the Agency. This report has not been
8 reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent
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*Did not participate in the review of the EPA's proposed methodology for updating mortality risk valuation estimates for policy analysis.

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*Did not participate in the review of the EPA's proposed methodology for updating mortality risk valuation estimates for policy analysis.

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Acronyms and Abbreviations

BLS	U.S. Bureau of Labor Statistics
CFOI	Census of Fatal Occupational Injuries (U.S. Bureau of Labor Statistics)
COFI	Cost of Funds Index
CPS	Current Population Survey
CV	Contingent Valuation
FDA	U.S. Food and Drug Administration
FES	Fixed Effect Size
GDP	Gross Domestic Product
IEVSL	Income Elasticity of Value of Statistical Life
NOAA	National Oceanic and Atmospheric Administration
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RES	Random Effect Size
STAR	Science to Achieve Results Program
VRR	Value of Risk Reduction for Mortality
WTP	Willingness to Pay

1. EXECUTIVE SUMMARY

The National Center for Environmental Economics in the EPA Office of Policy requested advice from the SAB on proposed improvements in the agency’s methodology for estimating benefits associated with reduced risk of mortality. This methodology takes into account the dollar amount that individuals are willing to pay for small reductions in mortality risk. The resulting values are combined into an estimate known as the value of statistical life (VSL) which is used in regulatory benefit-cost analysis. The EPA also requested that the SAB review options for accounting for changes in VSL over time as income grows, known as income elasticity of the VSL. The EPA submitted three documents to the SAB for review: (1) a white paper titled *Valuing Mortality Risk for Policy: a Meta-analytic Approach* (hereafter referred to as the “White Paper”); (2) a report by Robinson and Hammitt (2015) prepared for the EPA Office of Air and Radiation titled *The Effect of Income on the Value of Mortality and Morbidity Risk Reductions*; and (3) an EPA memorandum titled *Recommended Income Elasticity and Income Growth Estimates: Technical Memorandum*. The White Paper was developed to describe the EPA’s proposed approach for estimating values for reductions in mortality risk for use in benefit-cost analysis. This approach includes assembling a VSL dataset from the published stated preference and hedonic wage study literature and using non-parametric and parametric analytic methods to develop central estimates of the average VSL among the general U.S. adult population. The EPA report and technical memorandum on income elasticity of VSL discuss options for updating the agency’s recommended estimate for the income elasticity of the VSL.

The EPA asked the SAB to review the White Paper and other documents and respond to 19 charge questions that focused on: (1) whether the methods used to select the data set for the analysis were appropriate and scientifically sound, (2) whether relevant empirical studies were adequately captured in the White Paper, (3) whether the methodology used in the White Paper to analyze the data represents an appropriate and scientifically sound application of meta-analytic methods to derive VSL estimates; (4) whether the EPA’s proposed VSL estimates represent reasonable and scientifically sound conclusions; (5) development of a protocol for future updates of the VSL; and (6) whether EPA’s approach to estimating the income elasticity of VSL was appropriate and scientifically sound. This executive summary highlights the findings and recommendations of the SAB in response to the charge questions provided in Appendix A.

Evidence of Validity of the Stated Preference Studies

The SAB finds that the evidence of study validity considered by the EPA is appropriate but incomplete. To strengthen the assessment of study validity, the agency should consider a broader set of criteria for validity. In addition, the EPA should clarify how their criteria of validity were applied to all of the studies that were considered for use in the analysis.

Construct of the Risk Variable in Hedonic Wage Studies

The SAB was asked to comment on whether the hedonic wage studies included in the White Paper constructed the risk variable in a manner appropriate for use in the meta-analysis. In the White Paper the EPA used hedonic wage studies and estimates where the risk measure is differentiated by industry and at least one other characteristic (e.g., occupation, gender, age). The SAB finds that the use of “industry and one other characteristic” risk measures is not appropriate for characteristics such as gender or age. This

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1 is because the risks are likely to be too varied within an industry group and because wage discrimination
2 might affect the wage-risk differential across some groups. The SAB recommends that the analysis to
3 determine the VSL only include hedonic studies where the risk variable includes variation by
4 occupation, either with respect to occupation and industry or with respect to occupation only.
5

6 **Estimates of Value of Immediate Risk Reduction**

7
8 The SAB was asked to comment on whether appropriate estimates from the stated preference literature
9 were used in the White Paper to estimate the marginal willingness to pay for reduced risk of immediate
10 death. The SAB has provided citations for several additional studies that could be included in the White
11 Paper. In addition, the SAB finds that the supplementary analysis in one of the studies the EPA selected
12 for use, Viscusi, Huber, and Bell (2014), does not provide clear evidence of study validity (i.e.,
13 sensitivity of scope). Moreover, the SAB recommends that the EPA broaden the scope of studies used to
14 derive values for reducing both mortality and morbidity risks. There are a significant number of
15 published studies that estimate willingness to pay for improved health and reduced health risks, and a
16 literature on benefit-risk and risk-risk tradeoff preferences in health and health care that could enrich the
17 evidence on risk preferences and provide support for benefits-transfer applications. The SAB also finds
18 that discounting does not correctly account for the effect of time on VSL. The EPA should use a more
19 correct construct such as the value of statistical life-years lost rather than the present value of a future
20 statistical death.
21

22 **Empirical Studies**

23
24 The SAB was asked to comment on whether relevant empirical studies in the stated preference and
25 hedonic wage literatures are adequately captured in the White Paper. There has been a lack of significant
26 growth in the VSL literature since the last consideration of this topic by the SAB in 2011. As previously
27 indicated, the SAB has provided citations for several additional studies that could be included in the
28 White Paper. However, the SAB also recommends that the agency consider commissioning more studies
29 or creating other incentives for new studies to improve the prospect for a deeper literature to support
30 future reviews of VSL. The White Paper should also contain more detail or information to allow readers
31 to assess how the reliance on published studies, particularly other meta-analyses (including studies that
32 drew from international data), might lead to results that differ due to publication bias, lags in
33 publication, or other concerns.
34

35 **Population Weighting in EPA’s Analysis**

36
37 The SAB was asked to comment on whether the population-weighting approach used in the White Paper
38 to approximate a VSL estimate for the general population is appropriate and scientifically sound. Some
39 estimates in the meta-analysis dataset in the White Paper are constructed by weighting subpopulation-
40 specific estimates within a study in order to approximate an estimate for the general population. Given
41 the limited VSL literature, the SAB recognizes the need to develop a weighting approach to use
42 subpopulation estimates of VSL in the analysis. However, additional information is needed in the White
43 Paper to explain how the weighting was actually done and how the studies were brought together for the
44 aggregate estimate. The White Paper should contain a more detailed explanation of how weighting
45 procedures would affect estimates of standard errors. In addition: (1) the implications of selection bias in
46 survey-based studies should be explained; (2) greater consideration should be given to details of the

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1 specific studies being weighted; (3) weights should be connected to the time periods of the original
2 studies; (4) there should be an adjustment for income differences in the populations in individual
3 studies; (5) the EPA should explain how Hicksian and Marshallian measures of VSL were aggregated;
4 and (5) the weighting process used for the specific studies listed in Appendix B of the White Paper
5 should be clarified. The EPA should also consider undertaking future work to investigate the possibility
6 of developing a more complex set of subpopulation weights that build upon what is known about the
7 subpopulations covered in each of the available studies. <<*Chair’s note: please clarify this sentence*>>
8

9 **Estimation of Standard Errors**

10
11 In the White Paper, the EPA attempts to estimate the standard errors of the VSL when the original
12 studies do not report them. The SAB was asked to comment on whether the methods used to estimate
13 these standard errors are appropriate and scientifically sound. The SAB finds that the white paper does
14 not provide detailed information about how the standard error of the VSL is calculated when the original
15 studies do not report it. A detailed description of the method, including the formula used in the
16 calculation for each study, should be provided in the White Paper. The White Paper also uses a bootstrap
17 approach to estimate standard errors for non-parametric VSL estimates. The SAB proposes an
18 alternative, perhaps theoretically better, way to calculate standard errors for each non-parametric VSL
19 estimator.
20

21 **Overall Methodology for Analyzing the Data**

22
23 The SAB was asked to comment on whether the methodology used in the White Paper to analyze the
24 data represents an appropriate and scientifically sound application of meta-analytic methods to derive
25 generally applicable VSL estimates for environmental policy analysis. In general, the SAB finds that the
26 meta-analytic methods used in the White Paper appear to be scientifically sound and consistent with
27 standard and accepted practices for conducting meta-analyses. However, the SAB recommends that the
28 White Paper more explicitly discuss the standard and accepted practices for conducting meta-analysis
29 and how they have been applied. In particular, the EPA should: (1) refer to standard “fixed effect size
30 (FES)” and “random effect size (RES)” methods, that are fundamentally similar to the “sampling error”
31 and “total error” variance weighted mean approaches used in the White Paper, and describe how the
32 White paper departs from these more standard practices; (2) provide more detail about each of the
33 primary studies and the selected value estimates in a way that reinforces the direct comparability of the
34 objects/commodities being valued; (3) discuss and make adjustments for differences in the effect size
35 measures across studies of value estimates (e.g., the types of assumptions that would be needed to
36 convert Marshallian to Hicksian measures); (4) conduct non-parametric and parametric analyses without
37 adjusting VSL values to account for differences in income but include an income measure as an
38 explanatory variable in the parametric meta-regression; and (5) justify the use of “sample size weighted
39 mean” in the non-parametric analysis.
40

41 **Grouping Samples for Analysis**

42
43 The White Paper classifies estimates into independent samples, also called groups. Estimates from some
44 hedonic wage studies that use the same or very similar worker samples are grouped together for the
45 analysis. Similarly, some of the stated preference estimates using the same sample are grouped together.
46 The SAB was asked to comment on whether this methodology represents an appropriate and

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1 scientifically sound approach for accounting for potential correlation of results that rely on the same
2 underlying data. The SAB supports grouping the studies in the White Paper based on similar samples to
3 account for the lack of independence in estimates constructed from the samples. However, additional
4 detail should be provided to clarify how the grouping decisions were made. The SAB also recommends
5 that the EPA conduct additional analysis to check the robustness of the results to different plausible
6 group definitions. This robustness check should include: (1) exploring the sensitivity of results to
7 alternative group assignments; (2) using the influence analysis to examine the robustness of results to
8 excluding each group; and (3) identifying the primary estimate from each study and re-estimating the
9 meta-regression using only primary estimates.

10
11 **Addressing Sampling and Non-Sampling Errors**

12
13 The White Paper presents an expression that characterizes optimal weights that account for sampling
14 and non-sampling errors. The SAB was asked to comment on whether this is an appropriate and
15 scientifically sound approach for addressing sampling and non-sampling errors. Additional information
16 is needed to fully address this question. Derivation of the expression characterizing optimal weights that
17 account for sampling and non-sampling errors should be explained in a more transparent way in the
18 White Paper. Therefore, the SAB recommends including the various steps required to derive equation 4
19 in Section 4.1. Citations establishing the validity of the basic approach, if not the literal equation, should
20 also be included. With regard to use of the weights, clarification of and justifications for the assumptions
21 regarding the error components should be included in the White Paper. In addition, the SAB
22 recommends that transparency be applied as a criterion for selecting an estimator.

23
24 **Non-parametric and Parametric Approaches for Estimating Value of Statistical Life**

25
26 The White Paper adopts both non-parametric and parametric approaches to estimate a VSL. The SAB
27 was asked to comment on whether these approaches span a reasonable range of appropriate,
28 scientifically sound, and defensible approaches to estimating a broadly applicable VSL for
29 environmental policy and whether there are other methods that are more appropriate than those used in
30 the White Paper. The SAB finds that additional information is needed in the White Paper to explain how
31 these approaches were applied. Citations should be provided for the non-parametric approaches and
32 better justification should be provided to explain why the methods used are relevant to finding the
33 central tendency of VSL estimates from studies that, in most cases, report multiple estimates. The SAB
34 supports the EPA's conclusion that the mean of group means estimator is the preferred non-parametric
35 method because it has the smallest estimated standard error. However, the EPA should also justify use of
36 the mean of group means estimator on the grounds that it avoids giving more weight to papers that
37 report more estimates. In addition, the SAB recommends that: (1) the EPA explore the use of an
38 alternative non-parametric method that incorporates information on sampling error variance from each
39 study; (2) for the parametric estimator, the EPA provide a better explanation of and justification for the
40 included control variables; and (3) the EPA be consistent in its treatment of the time trend in VSL
41 estimates.

42
43 **Proposed Estimates of Value of Statistical Life**

44
45 The White Paper presents VSL estimates using parametric and non-parametric models, pooled across
46 stated preference and hedonic wage studies as well as balanced (i.e., giving equal weight to each study

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1 type), and weighted using different approaches. The EPA has proposed using the non-parametric model
2 balanced mean of study means VSL estimate and the parametric model balanced VSL estimate. The
3 SAB was asked to comment on whether these proposed estimates represent reasonable and scientifically
4 sound conclusions from the analyses in the White Paper and whether there is a different set (or sets) of
5 results that are preferable based on the data and analysis in the White Paper. As previously stated, the
6 EPA’s VSL estimates for the U.S. population were developed using a meta-analytic approach that
7 appears to be consistent with standard and accepted practice. However, the SAB recommends that the
8 EPA also consider using the non-parametric sampling error variance weighted group mean in place of
9 the non-parametric mean of group means estimator. The SAB also recommends that the documentation
10 of income adjustment to VSL be clarified in the White Paper. Adjustment of VSL estimates by an
11 income elasticity of VSL and index of income growth (based on GDP per capita) does not seem to be
12 appropriate. However, conversion of VSL to inflation adjusted dollars would be appropriate.

13
14 **Influence Analysis**

15
16 The results section of the White Paper concludes with an influence analysis. The SAB was asked to
17 comment on whether the influence analysis is a reasonable way to characterize the influence of
18 individual studies on the estimated VSLs, whether the results of the influence analysis suggest any
19 changes or modifications to the EPA’s estimation approach, and whether it is important to include an
20 influence analysis. The SAB agrees that some form of influence analysis is important for meta-analysis
21 in cases where there are few studies to consider, and therefore one or two individual studies might have
22 a substantial influence on the estimates. Influence analysis of the maximum likelihood stated preference
23 estimates in the White Paper indicates that the Corso, Hammitt and Graham (2001) study is well over
24 two times more influential than the second most influential study. Therefore, the SAB recommends that
25 the EPA consider using a robust estimation technique that limits the influence of this observation. The
26 SAB also recommends that the EPA consider the potential for using regression diagnostic indexes for
27 the parametric modeling of VSL.

28
29 **Criteria for Inclusion and Exclusion of VSL Estimates in Future Analyses**

30
31 The SAB was asked to comment on relevant statistical criteria for the inclusion of additional eligible
32 VSL estimates and/or the exclusion of older VSL estimates that could help inform the development of a
33 standardized protocol for future updates and the timing or frequency of those updates. The SAB finds
34 that a five year interval for updating VSL estimates is appropriate, but there is a need to increase the
35 pool of high quality studies to support the VSL meta-analysis. To accomplish this, the EPA should: (1)
36 consider whether estimation of VSL and its various attributes should be a high priority topic for EPA
37 grants and fellowships, sponsored conferences, special issues of journals, and awards; (2) consider the
38 feasibility of sponsoring a refereed journal that focuses on analyses of direct relevance to meeting the
39 agency’s needs; and (3) obtain more general information about protocols for updating estimates from the
40 experience of other agencies that construct economic index numbers for policy.

41
42 The SAB also recommends that: (1) there should be a single set of criteria for determining which studies
43 are of sufficient quality to be included in current and future estimates of VSL; (2) the EPA should not
44 restrict studies used for updating VSL to those published in peer-reviewed journals (studies outside of
45 the peer-reviewed journals should be considered for inclusion following a transparent and rigorous peer
46 review process) <<*Chair’s note: this statement should be discussed by the Committee*>> ; (3) the EPA

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1 should consider whether useful information can be extracted from other studies that could improve
2 estimates of VSL and its characteristics (e.g., latency, morbidity); (4) the EPA should not exclude
3 studies based on non-national samples from use in updating VSL as long as there is a set of studies that
4 as a group is representative of the nation as a whole; and (5) the EPA should consider a long term
5 strategy of requiring that a more inclusive set of research results, and even whole data sets, be made
6 generally available for use by the research community and by government agencies.

7
8 **Valuing Reductions in Risks of Cancer**

9
10 The SAB was asked to comment on whether the selection criteria for identifying studies for valuing
11 reductions in risks of cancer mortality should differ from those used in the current White Paper. The
12 SAB was also asked whether the literature supports a non-zero differential between valuation of cancer
13 and other mortality risk. Based on available studies, the SAB concludes that there is not sufficient
14 evidence at this time to justify a non-zero cancer differential. The SAB recommends that, instead of
15 adopting a non-zero cancer differential, the EPA consider using existing methods to value the morbidity
16 that occurs prior to an early death and add that estimated morbidity value to conventional estimates of
17 the value of the associated mortality. The EPA currently values morbidity from cancer in cases where
18 the cancer is not fatal, but does not value morbidity in fatal cancer cases. The EPA should value cancer
19 morbidity regardless of whether that morbidity leads to an early death. This recommendation also
20 applies to other environment-related mortality risks, including cardio-pulmonary disease. In addition, the
21 EPA should encourage and support ongoing research on whether willingness to pay to reduce the risk of
22 an early death preceded by a period of morbidity is correctly valued by summing the value of the
23 morbidity plus the value of the mortality. At this time, the SAB does not have evidence to suggest that
24 approach would over- or under-state the true willingness to pay.

25
26 **Income Elasticity Literature**

27
28 The SAB was asked to comment on whether the report by Robinson and Hammitt (2015) and the EPA
29 Technical Memorandum provide an appropriate and scientifically sound summary of the income
30 elasticity of VSL and income elasticity of non-fatal health effects literatures. The SAB finds that the
31 Robinson and Hammitt (2015) and the EPA document *Technical Memorandum: Income Elasticity*
32 provide reasonable summaries of the income elasticity literature. However, the SAB has provided
33 citations for some additional studies that should be included in the summary of the literature. Very few
34 studies have been conducted on the income elasticity of the value of statistical life. The SAB therefore
35 recommends that the EPA consider the possibility of using estimates of the income elasticity for other
36 related goods and services to infer estimates of the income elasticity of the value of statistical life. Going
37 forward, the EPA should support more research to provide methodological guidance and empirical
38 estimates in this important area.

39
40 **Analysis of Very Low Income Elasticity Estimates**

41
42 The “balanced” approach in the EPA Technical Memorandum on estimating income elasticity of VSL
43 does not include reported mean estimates of zero, but does include very low reported mean estimates.
44 The SAB was asked to comment on: (1) whether this an appropriate and scientifically sound choice, and
45 (2) how very low, non-zero, mean reported income elasticity results should be addressed in the EPA’s
46 analysis. The SAB finds that it is highly unlikely for the income elasticity of VSL to be zero or negative.

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1 However, to address the issue of low/zero estimates, the SAB recommends that, instead of calculating an
2 unweighted mean of income elasticity of VSL estimates, the EPA should use standard errors of
3 individual income elasticity of VSL estimates to calculate a weighted mean. The EPA should also
4 calculate the weighted mean of the income elasticity of VSL both with and without the low/zero
5 estimates to assess their influence.

6
7 **Study Selection Criteria and Alternative Approaches for Estimating Central Income**
8 **Elasticity of Value of Statistical Life**

9
10 The SAB was asked to comment on whether the study selection criteria applied in the paper by
11 Robinson and Hammitt (2015) are appropriate and scientifically sound and whether the additional
12 inclusion of Viscusi, Huber, and Bell (2014) in the EPA Technical Memorandum is appropriate based
13 on results reported in the study's on-line appendix. In addition, the SAB was asked to comment on two
14 proposed alternatives for arriving at a central income elasticity of VSL. Robinson and Hammitt (2015)
15 have done an admirable job summarizing the available literature. However, their analysis, indicates that
16 there is not an adequate informational basis for deriving a consensus estimate of the income elasticity of
17 VSL. The inclusion of Viscusi, Huber and Bell (2014) does not alter this conclusion. The SAB finds that
18 neither of the two alternatives put forward in Robinson and Hammitt (2015) and described in EPA's
19 technical memorandum represent an adequate basis for providing an estimate of the income elasticity of
20 VSL for policy purposes. Therefore the SAB recommends that the EPA consider the alternative
21 approach of using the preferred VSL model specification to obtain and compare VSL estimates at
22 different points in time and use that to obtain the implied income elasticity of VSL.

23
24 **Income Elasticity of the Value of Non-fatal Health Effects**

25
26 The EPA's Technical Memorandum recommends using the income elasticity of VSL to estimate income
27 elasticity for the value of non-fatal health risks. The SAB was asked to comment on whether this
28 represents an appropriate and scientifically sound approach given the available data. The SAB does not
29 fully support using the income elasticity of VSL to estimate income elasticity for the value of non-fatal
30 health risks because it is conceptually incorrect to apply income elasticity for one good to some other
31 good. The SAB recommends that the EPA explore use of the income elasticity of expenditures on
32 private health care products as a better proxy for the income elasticity of non-fatal health risks.

2. INTRODUCTION

The National Center for Environmental Economics in the EPA Office of Policy requested advice from the SAB on proposed improvements in the agency’s methodology for estimating benefits associated with reduced risk of mortality. This methodology takes into account the amounts that individuals are willing to pay for reductions in mortality risk. The resulting values are combined into an estimate known as the value of statistical life (VSL) which is used in regulatory benefit-cost analysis. The EPA also requested that the SAB review options for accounting for changes in VSL over time as income grows, known as income elasticity of the VSL. The EPA submitted three documents to the SAB for review: (1) a white paper titled *Valuing Mortality Risk for Policy: a Meta-analytic Approach* (hereafter referred to as the “White Paper”); (2) a report by Robinson and Hammitt (2015) prepared for the EPA Office of Air and Radiation titled *The Effect of Income on the Value of Mortality and Morbidity Risk Reductions*; and (3) an EPA memorandum titled *Recommended Income Elasticity and Income Growth Estimates: Technical Memorandum*.

The White Paper was developed to describe the EPA’s proposed approach for estimating values for reductions in mortality risk for use in benefit-cost analysis. This approach includes assembling a VSL dataset from the published stated preference and hedonic wage study literature and using non-parametric and parametric analytic methods to develop central estimates of the average VSL among the general U.S. adult population. The EPA report and technical memorandum on income elasticity of VSL discuss options for updating the agency’s recommended estimate for the income elasticity of the VSL.

The EPA asked the SAB to review the White Paper and other documents and respond to 19 charge questions that focused on: (1) whether the methods used to select the data set for the analysis were appropriate and scientifically sound, (2) whether relevant empirical studies were adequately captured in the White Paper, (3) whether the methodology used in the White Paper to analyze the data represents an appropriate and scientifically sound application of meta-analytic methods to derive VSL estimates; (4) whether the EPA’s proposed VSL estimates represent reasonable and scientifically sound conclusions; (5) development of a protocol for future updates of the VSL; and (6) whether EPA’s approach to estimating the income elasticity of VSL was appropriate and scientifically sound. In response to the EPA’s request, the SAB convened its Environmental Economics Advisory Committee to conduct the review. The Committee held a public meeting on March 7-8, 2016 to deliberate on the charge questions and develop a consensus report of its findings and recommendations. This SAB report provides the findings and recommendations of the SAB in response to the EPA charge questions (Appendix A.). The SAB recommendations are highlighted at the end of each section of this report.

3. RESPONSES TO EPA’S CHARGE QUESTIONS

3.1. Meta-Analysis Dataset

3.1.1. Evidence of Validity of the Stated Preference Studies

Charge Question 1a. Evidence of validity for stated preference studies: The SAB noted in its earlier advisory report (U.S. EPA Science Advisory Board 2011) that each selected stated preference study “should provide evidence that it yields valid estimates” (page 16). The SAB did not, however, specify how validity should be assessed. In applying this criteria, EPA included studies and estimates that passed a weak scope test or provided other evidence of validity (e.g., a positive coefficient on the risk variable as in the appendix for Viscusi, Huber and Bell 2014) as explained in Appendix B of the White Paper. Please comment on whether the methods EPA used in the White Paper to assess the validity of studies and estimates are appropriate and scientifically sound.

The SAB previously recommended that specific criteria be used in identifying appropriate stated preference studies to estimate the Value of Statistical Life (EPA SAB 2011). In particular, the SAB recommended that the EPA use only estimates with evidence of validity, such as passing a scope test (i.e., showing that willingness to pay increases with the size of risk reduction within or between samples of respondents in a stated preference study). The EPA indicated that it applied the SAB’s recommended criteria in selecting the studies used in the 2016 White Paper and has asked the SAB to comment on whether the methods used to assess the validity of the studies and estimates are appropriate and scientifically sound.

The SAB finds that that the evidence of validity considered by the EPA in selecting studies for use in the 2016 White Paper is appropriate but incomplete. The following aspects of the methodology for assessing validity should be clarified:

- 1) Application of the methods to assess study validity. It is not clear how the EPA applied the evidence of validity across all studies included in the analysis and whether the same criteria were applied to all studies (both the included and excluded studies).
- 2) The list of factors considered as evidence of validity is incomplete, especially with regard to study design and administration features. In order to strengthen the assessment of study validity and better inform a weight of evidence decision to include or exclude a study, the SAB recommends that the EPA expand the consideration of evidence of validity to include answers to the additional key questions discussed below.
- 3) Threshold for inclusion or exclusion of studies. It is not clear how, or if, evidence of validity was used to exclude or include studies and observations in the data set used by EPA. Excluded studies and observations are identified in the White Paper, but all of the exclusions may not be justified. The white paper appendix that discusses assessment of validity (Appendix B) is silent on the investigations of validity for some studies. In addition, the threshold for inclusion of studies and observations is not clearly stated in the White Paper.

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1 *Study Validity*
2

3 Three important concepts of stated preference study validity should be considered – content, construct
4 and criterion (Carmines and Zeller 1979). Content validity takes into consideration the use of established
5 procedures to implement a method (e.g., U.S. EPA’s *Guidelines for Preparing Economic Analyses*);
6 construct validity involves the testing of specific procedures (e.g., procedural invariance, convergent
7 validity, tests of scope, etc.); and criterion validity involves comparison of empirical outcomes against a
8 presumed truth (e.g., comparisons with cash transactions).
9

10 There is no perfect study and no absolute test of validity. Content validity only implies that the
11 likelihood of unbiased estimates is enhanced or, perhaps, that bias is reduced. Satisfying construct
12 validity establishes the credibility of a specific procedure in implementing a stated-preference study.
13 Like content validity, construct validity implies that the likelihood of unbiased estimates is enhanced or
14 that bias is reduced. Criterion validity is the strongest concept of validity as it speaks directly to bias, but
15 the outcome is only as credible as the credibility of the criterion, the measure of the presumed truth.
16 Thus, validity assessment depends on considering the weight of evidence and is a matter of judgment.
17 The SAB suggests some criteria for weighing the evidence of validity below.
18

19 The evidence of validity considered in the current draft of the White Paper includes sensitivity to scope
20 and question ordering effects (i.e., the order of presentation of valuation questions in the stated
21 preference survey should not affect responses and corresponding willingness to pay estimates).
22 However, it is not clear whether the EPA applied these validity tests to all studies used in the analysis or
23 just to those studies where such evidence was made available by the authors. Therefore, the SAB
24 recommends that in the White Paper the EPA provide a table that lists the evidence of validity that was
25 available (or not) for each of the studies excluded from and included in the agency’s analysis. The EPA
26 should document in this table whether the evidence of validity was used to support exclusion or
27 inclusion of studies and observations within studies.
28

29 *Evidence of Study Validity*
30

31 Scope and question ordering effect fall under the concept of construct validity. Evidence of scope and
32 lack of a question ordering effect (procedural invariance) are evidence of validity. It is logical to expect
33 willingness to pay for a larger reduction in risk and one would not expect value estimates to change with
34 the sequence of where a stated preference was placed in a survey, but this need not be the case.
35 A scope failure or a question sequencing effect, while reason for concern, does not mean a value
36 estimate is invalid. Tests of scope imply structure on respondent preferences that are imposed by the
37 investigators and that may or may not be true (Van Houtven et al. 2011). The basic axioms of choice
38 only imply that marginal willingness to pay for a larger reduction in risk should be nonnegative, not that
39 it should be positive and significantly different from zero or further, proportional to the risk change.
40 Thus, excluding studies with an insignificant scope effect may lead to an overestimation of value.
41 Violation of procedural invariance, due to a question ordering effect, does not establish whether one or
42 both value estimates are biased. In fact, both estimates could be valid within the sequence that the
43 questions were asked and procedural invariance would not be expected to apply (Carson, Flores and
44 Hanemann 1998). Thus, failure of a test of construct validity typically requires additional investigation
45 to understand if the failure is evidence of invalidity or that the stated preference estimate is valid and
46 unbiased.

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1
2 Further, not every study needs to conduct nor does conduct a construct validity investigation. This
3 makes it difficult, if not impossible, to consistently evaluate every stated preference study for evidence
4 of validity based on considerations of construct validity. On the other hand, content validity implies
5 considerations that should be elements of every stated preference question (Boyle 2003). Thus, evidence
6 of validity should consider both content and construct validity. A test of criterion validity is unlikely in
7 most studies and may be impossible in many applied studies. Therefore, criterion validity is not
8 recommended as a required element of evidence of study validity.
9

10 In order to strengthen the assessment of study validity and better inform a weight of evidence decision to
11 include or exclude a study, the SAB recommends that the EPA expand the consideration of evidence of
12 validity to include answers to the following key questions:
13

- 14 – Was the survey pretested using focus groups, one-on-one interviews, or field pretest?
- 15 – Was the survey applied to a random sample of a clearly specified population?
- 16 – Did the survey clearly define the baseline risk?
- 17 – Did the survey clearly explain the change in risk to be valued?
- 18 – Was the sample of respondents investigated for comparability to the population sampled?
- 19 – Was the stated preference question a binary choice framed as a referendum or product
- 20 purchase where payment would be required if the risk change was provided?
- 21 – Were robustness checks conducted of the statistical analyses that led to the value estimate?
- 22 – Were construct validity tests conducted?
- 23 – Was the study published in a peer-reviewed journal or evaluated through a transparent and
- 24 rigorous peer review process?
25

26 The first seven items relate to content validity and should be elements in any credible stated-preference
27 study. Construct validity tests provide evidence of validity in one or more dimensions of the study
28 design and implementation. Construct validity could involve any tests of respondents' understanding of
29 the risk scenario and choice they are being asked to value. Peer review, not just in an academic journal
30 (e.g., M.S. and Ph.D. theses have peer review by graduate students' committees), is evidence that the
31 scientific validity of a study has been investigated by one or more peers. This broader consideration of
32 validity can inform the weight of evidence supporting the exclusion or inclusion of studies and
33 individual value estimates in the meta-analysis (Bishop and Boyle 2016).
34

35 *Judging the Weight of Evidence*
36

37 Validity decisions need to proceed with caution. For example, the elements of content validity may or
38 may not be reported in a journal article. As noted above, tests of construct validity are not a prerequisite
39 of any individual study and failure of construct validity does not necessarily imply invalidity. While
40 journal articles typically include a theoretical or methodological twist that will provide evidence of
41 construct validity, what is reported in journal articles may be constrained by space limitations and the
42 specific focus of the article. A broader consideration of peer reviewed and auxiliary supporting
43 documents may include studies with more policy-relevant value estimates and provide more evidence of
44 validity or invalidity. Thus, decisions on validity need to consider the weight of evidence from the
45 elements in the list above that are documented and available.
46

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1 There is no precedent in the stated preference literature to establish a standard for what is a valid or
2 invalid stated preference study. The closest analog is the National Oceanic and Atmospheric
3 Administration (NOAA) Blue Ribbon Panel report (Arrow et al. 1993), which lists a large number of
4 validity considerations for contingent valuation (CV) surveys, but does not clearly state that all validity
5 considerations must be met for a study to provide useful information. In fact, the NOAA Panel stated:
6

7 “... we try to lay down a fairly complete set of guidelines compliance with which
8 would define an ideal CV survey. A CV survey does not have to meet each of these
9 guidelines fully in order to qualify as a source of reliable information to a damage
10 assessment process. Many departures from the guidelines or even a single serious
11 deviation would, however, suggest unreliability prima facie.”
12

13 These guidelines were for studies done for estimating nonuse (or passive use) values to support natural
14 resource damage cases filed in court and where the government can recover the cost of conducting the
15 studies from the responsible party, whereas most valuation studies are conducted for academic purposes
16 or to inform policy decisions where the cost of the studies is a major consideration with hard budget
17 constraints that limit the possible design features. The lack of clear guidance on assessing validity
18 suggests that the EPA needs to proceed cautiously when making validity assessments. Therefore, the
19 SAB recommends careful documentation of studies that meet or do not meet validity criteria as
20 evidenced in the answers to the key questions listed above. Studies that are on the margin for
21 inclusion/exclusion in the meta-analysis should be carefully scrutinized (including sensitivity analyses)
22 to assess whether the potential threats to validity are likely to bias the value estimates.
23

24 *Other Validity Assessments*

25
26 The discussion above has focused on whether a specific stated preference study or observations within a
27 study are valid. There are also broader validity assessments that can be conducted to determine whether
28 a body of literature is valid and whether a method is valid. With regard to method validity, there can be
29 evidence in the literature that establishes whether stated preference design and implementation
30 procedures lead to valid value estimates. Thus, while a specific study may not provide evidence of
31 investigation of a specific design or implementation feature, it is possible to refer to the broad valuation
32 literature to assess validity. Validity of a body of empirical research, such as VSL estimates, can be
33 investigated through meta-regressions to consider points of validity and invalidity (Mrozek and Taylor
34 2002; Lindhjem et al. 2011). The SAB recommends that weight of evidence assessments of study
35 validity should be informed by consideration of the broad stated preference literature and pre-existing
36 meta-analyses of VSL.
37

38 *Updating the VSL Estimate*

39
40 It is important that the knowledge and assessment of study validity evolve through time as research
41 progresses. Future updates of the VSL should consider advancements in the literature pertaining to study
42 design, conduct, and testing relating to validity. An example of this is the current evolution in the
43 literature extending incentive compatibility through consequential survey designs (Carson, Groves and
44 List 2015). Such updating does not necessarily exclude older studies. For example, while
45 consequentiality has only entered the stated preference literature in recent years, many, if not most,
46 earlier studies following good practices were consequential. Therefore, the SAB recommends that all

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1 future updates of the VSL simultaneously consider whether the conditions for investigating study
2 validity should be updated.

3
4 *Identification of all Criteria for Study Inclusion/Exclusion*

5
6 The SAB finds that the White Paper could be improved by identifying: (1) all criteria for including
7 studies in the meta-analysis, and (2) all manipulations of value estimates that were performed to convert
8 the estimates to a homogenous metric that would support the meta-analysis (e.g., manipulation of the
9 value estimates in a study that has a well-defined baseline risk and risk change but is not consistent with
10 the other studies that are included in the meta-analysis). An example that does not affect validity, but
11 affects the measure of values and the computation of VSLs, is the time frame of payment (e.g., one time,
12 annual payment for a fixed period, continuing payments into perpetuity). Such criteria and
13 manipulations of value estimates should be identified even though they may not be fundamental to
14 investigation of the validity of VSL estimates. An enhanced listing of study features considered for
15 inclusion/exclusion of studies and observations, and a listing of the manipulations of the reported value
16 estimates, would avoid confusion between validity of the underlying values and validity of the meta-
17 analysis itself. Therefore, the SAB recommends that all criteria for inclusion/exclusion of
18 studies/observations be documented systematically across studies in a table similar to the one previously
19 recommended for documenting the investigation of study validity. This should be followed by a separate
20 table that documents manipulations of value estimates to convert value estimates to a homogenous
21 metric to support the meta-analysis.

22
23 *Key Recommendations*

- 24
- 25 • In the White Paper the EPA should provide a table that lists the evidence of validity that was or was
26 not available for each of the studies considered for inclusion in the agency's analysis. The EPA
27 should also document in this table whether the evidence of validity was used to support exclusion or
28 inclusion of studies and observations within studies.
 - 29
 - 30 • Consideration of evidence of study validity should be expanded to include answers to the following
31 questions:
32
 - 33 – Was the survey pretested using focus groups, one-on-one interviews, or field pretest?
 - 34 – Was the survey applied to a random sample of a clearly specified population?
 - 35 – Did the survey clearly define the baseline risk?
 - 36 – Did the survey clearly explain the change in risk to be valued?
 - 37 – Was the sample of respondents investigated for comparability to the population sampled?
 - 38 – Was the stated-preference question a binary choice framed as a referendum or product
39 purchase where payment would be required if the risk change was provided?
 - 40 – Were robustness checks conducted of the statistical analyses that led to the value estimate?
 - 41 – Were construct validity tests conducted?
 - 42 – Was the study published in a peer-reviewed journal or evaluated through a transparent and
43 rigorous peer review process?
 - 44
 - 45 • The EPA should clearly document all of the reasons why the included and excluded studies have or
46 have not met validity criteria. Studies that are on the margin for inclusion/exclusion in the meta-

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1 analysis should be carefully scrutinized (including sensitivity analyses) to assess whether the
2 potential threats to validity are likely to bias the value estimates.

- 3
- 4 • Evidence in the literature can be used to establish whether stated preference design and
5 implementation procedures lead to valid value estimates. Validity of a body of empirical research,
6 such as VSL estimates, can be investigated through meta-regressions. Therefore, weight of evidence
7 assessments of study validity should be informed by consideration the broad stated preference
8 literature and pre-existing meta-analyses of VSL.
- 9
- 10 • All future updates of the VSL should simultaneously consider whether the conditions for
11 investigating study validity should be updated.
- 12
- 13 • All criteria for inclusion/exclusion of studies/observations should be documented systematically
14 across studies in a table in the White Paper. This should be followed by a separate table that
15 documents manipulation of value estimates to convert the estimates to a homogenous metric to
16 support the meta-analysis.
- 17

18 **3.1.2. Construct of the Risk Variable in Hedonic Wage Studies**

19
20 *Charge Question 1b. Construct of the risk variable in hedonic wage studies: The SAB noted in*
21 *its earlier advisory that the EPA should “Eliminate any study that relies on risk measures*
22 *constructed at the industry level only (not by occupation within an industry)” (U.S. EPA Science*
23 *Advisory Board 2011, page 18). It is not clear whether the SAB’s parenthetical addition was*
24 *meant as an example or as a directive. Only four studies constructed the risk variable by*
25 *occupation and industry and met other selection criteria. In applying this criteria EPA included*
26 *studies and estimates where the risk measure is differentiated by industry and at least one other*
27 *characteristic (e.g., occupation, gender, age). Please comment on whether the hedonic wage*
28 *studies included in the White Paper constructed the risk variable in a manner appropriate for*
29 *use in the meta-analysis.*
30

31 The VSL analysis in EPA’s White Paper was conducted using hedonic wage studies where the risk
32 measure is differentiated by industry and at least one other characteristic (e.g., occupation, gender, age).
33 The SAB finds that the use of “industry and one other characteristic” risk measures is not appropriate for
34 characteristics such as gender or age. This is because the risks are likely to be too varied within an
35 industry and because wage discrimination might affect the wage-risk differential across some groups.
36 Therefore, the SAB recommends that the analysis to determine the final VSL summary measure only
37 include hedonic studies where the risk variable includes variation by occupation – either with respect to
38 occupation and industry or with respect to occupation only. One example of an “occupation-only”
39 hedonic wage study that should be included in the analysis is Delaire, Khan, and Timmins (2013).
40

41 The SAB also recommends that the EPA include in the White Paper a summary of recent meta-analyses
42 of hedonic wage studies. The summary should provide information about how the results of those
43 studies vary according to study design and data sources (e.g., alternative risk measures, studies without a
44 morbidity risk measure, sub-national geography within the U.S., and possibly studies from other
45 countries). This will enable the White Paper to convey the likely sensitivity of the final VSL summary

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1 measure to variations in the set of studies included in the calculations without having to repeat the work
2 already done in those meta-analyses.

3
4 *Enhancing the Quality of VSL Estimates Generated by Hedonic Wage Studies*

5
6 The SAB finds that research is needed to enhance the quality of VSL estimates generated by hedonic
7 wage studies. It is recommended that the EPA pursue research in the areas discussed below. The agency
8 should examine existing research and either conduct new research or encourage others to undertake
9 research to enhance the quality of future updates of the VSL.

10
11 The SAB is notes that the VSL generated by hedonic wage studies may be systematically biased relative
12 to the VSL for the whole population obtained from stated preference studies. The following four
13 potential biases are noted. These are evenly split between upward and downward biases.

- 14
15 1. Limited worker awareness of risks or limited worker mobility across jobs could lead the hedonic
16 VSL to understate workers' true preferences.
- 17
18 2. Sorting of risk-averse workers into safer jobs could lead the hedonic VSL to understate the
19 average preferences of the whole population.
- 20
21 3. The hedonic sample includes only workers. They may have higher income than the rest of the
22 population and this could lead the hedonic VSL to overstate the average preferences of the whole
23 populations.
- 24
25 4. The hedonic VSL is related to a Marshallian willingness to accept which could overstate the
26 Hicksian willingness to pay measure.

27
28 The SAB notes that a simple algebraic formula (and some assumptions) could identify how large an
29 adjustment would be needed to convert the Marshallian measure to the Hicksian one. This approach is
30 described in Smith, et. al. (2006). An assessment of the magnitude of this adjustment could be conducted
31 immediately to determine the importance of this issue.

32
33 The SAB also notes that existing hedonic wage studies are often based on different models or data from
34 different sources and therefore it may be difficult to find future published hedonic wage studies that
35 carefully apply existing hedonic wage models to new data. The EPA should consider applying a
36 consistent hedonic wage model to the available years of data, combining an industry and occupation risk
37 measure from the U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI) with the
38 U.S. Bureau of Labor Statistics March Current Population Survey (CPS) wage information, and
39 generating measures of VSL on a consistent basis. Estimates for future years should be added as the data
40 become available. This research would be relatively inexpensive to conduct, and could be done by EPA
41 staff or by other researchers. This research would assist EPA in systematically updating VSL numbers
42 over time.

43
44 In addition, the SAB notes that differences in estimated VSL across analyses using different risk
45 measures are not well understood. This limits the set of hedonic wage studies that can be included in the
46 VSL calculation. Viscusi (2004) examines both an industry-only risk measure and an industry and

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1 occupation risk measure using the same sample and the same model. The results run counter to the
2 classical measurement error model, which predicts lower impacts for the industry-only risk measure
3 because everyone in the same industry is mistakenly assigned the same risk. Instead, the industry-only
4 VSL results are twice as large as the industry and occupation results. Understanding why these
5 differences occur could provide guidance on which combinations of industry and other characteristics
6 would be appropriate for calculating the risk measure in hedonic wage studies.

7
8 *Key Recommendations*

- 9
- 10 • The analysis to determine the final VSL summary measure should only include those hedonic studies
11 where the risk variable includes variation by occupation – either with respect to occupation and
12 industry or with respect to occupation only.
 - 13
 - 14 • EPA should include in the White Paper a summary of recent meta-analyses of hedonic wage studies.
15 The summary should provide information about how the results of those studies vary according to
16 study design and data sources (e.g., alternative risk measures, studies without a morbidity risk
17 measure, sub-national geography within the US, and possibly studies from other countries).
 - 18
 - 19 • An assessment should be conducted to determine the magnitude of the adjustment needed to convert
20 the hedonic (willingness to accept) VSL to a Hicksian willingness to pay measure.
 - 21
 - 22 • A consistent hedonic wage model should be applied to the available years of data, combining an
23 industry and occupation risk measure from the U.S. Bureau of Labor Statistics Census of Fatal
24 Occupational Injuries (CFOI) with the U.S. Bureau of Labor Statistics March Current Population
25 Survey (CPS) wage information, and generating measures of VSL on a consistent basis.
 - 26
 - 27 • Research should be undertaken to develop a better understanding of differences in estimated VSL
28 across analyses using different risk measures.
 - 29

30 **3.1.3. Estimates of Value of Immediate Risk Reduction**

31
32 *Charge Question 1c. Estimates for immediate risk reductions: To estimate the average value of*
33 *the marginal willingness to pay for reduced risk of immediate death, the EPA selected estimates*
34 *from the stated preference literature that are most closely comparable to the accidental deaths*
35 *from the hedonic wage literature. The EPA made several judgment calls in determining the*
36 *appropriate estimates to use from the stated preference literature. Specifically, Viscusi, Huber*
37 *and Bell (2014) estimate reductions in risk of bladder cancer that will occur in 10 years. The*
38 *authors discount the estimates to derive a comparable estimate for an immediate risk reduction.*
39 *Alberini, et al. (2004) estimate a willingness to pay for an annual reduction in risk over 10*
40 *years. We include estimates from both of these studies in the meta-analysis. Please comment on*
41 *whether appropriate estimates from the stated preference literature were used in the White*
42 *Paper to estimate the marginal willingness to pay for reduced risk of immediate death.*
43

44 The SAB was asked to comment on whether the agency selected appropriate estimates from the stated
45 preference literature for its analysis of willingness to pay for reduced risk of immediate death. As
46 discussed in Section 3.1.4 of this report, the SAB has provided citations for several additional VSL

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1 studies that could be included in the White Paper. In addition, the SAB finds that the supplementary
2 analysis in one of the studies selected by the EPA for use, Viscusi, Huber, and Bell (2014), does not
3 provide clear evidence of study validity (i.e., sensitivity of scope).

4
5 *Use of a Benefits-Transfer Approach*

6
7 Moreover, the SAB finds that, as in other areas of environmental valuation, the limited available VSL
8 literature points to use of a benefits transfer approach. EPA should consider using best practice benefits-
9 transfer methods that employ principled adjustments in existing estimates to fit the particular policy
10 problem of interest. In contrast, meta-analysis relies heavily on a statistical weighting of evidence to
11 produce a single value.

12
13 The SAB recommends broadening the scope of studies the EPA uses to derive values for reducing both
14 mortality and morbidity risks. There are a significant number of published studies that estimate
15 willingness to pay for improved health and reduced health risks (see studies listed in Appendix B of this
16 report). There also is a burgeoning literature on benefit-risk and risk-risk tradeoff preferences in health
17 and health care that could provide a basis for enriching the evidence base on risk preferences and
18 providing support for benefits-transfer applications (see studies listed in Appendix C of this report).
19 Unlike the expected small increments in the VSL literature over the foreseeable future, there is a strong
20 demand and growing funding for stated preference benefit-risk studies in health and health care as the
21 result of recent U.S. Food and Drug Administration (FDA) regulatory guidance on conducting such
22 studies (U.S. Department of Health and Human Services 2015).

23
24 *Other Concerns about the Estimation of Willingness to Pay for Reduced Risk of Immediate Death*

25
26 The SAB also notes the following additional concerns about EPA's general approach to estimation of
27 willingness to pay for reduced risk of immediate death.

- 28
29
- 30 1. The risk of immediate death is not a policy-relevant outcome. Virtually all deaths of policy
31 interest occur with latency and are preceded by a period of morbidity and disability, including
32 potential pain and discomfort associated with treatment as well as the ultimately fatal condition
33 itself.
 - 34 2. Discounting does not correctly account for the effect of time on VSL. Dying immediately means
35 fewer years of life, not just a delay in a financial payment. A more correct construct would be the
36 value of statistical life-years lost rather than the present value of a future statistical death.
 - 37
38 3. Survey respondents may not be able to evaluate long-latency risks so value estimates of future
39 risks may be imprecise.
 - 40
41 4. EPA used estimates of willingness to pay for reduced risk of immediate death (Viscusi, Huber,
42 and Bell 2014). In this study the authors estimate reductions in risk of bladder cancer that will
43 occur in 10 years. A discount rate of three percent was applied to derive a comparable estimate
44 for an immediate risk reduction. The SAB finds that the selection of a three percent discount rate
45 is arbitrary and recommends that the EPA use a more correct construct such as the value of
46 statistical life-years lost rather than the present value of a future statistical death.

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Key Recommendations

- The SAB has provided citations for several additional studies that could be included in the White Paper. In addition, the SAB finds that one of the studies selected for use, Viscusi, Huber, and Bell (2014), does not provide clear evidence of study validity (i.e., sensitivity of scope).
- The SAB recommends that the EPA broaden the scope of studies used to derive values for reducing both mortality and morbidity risks. There are a significant number of published studies that estimate willingness to pay for improved health and reduced health risks and a burgeoning literature on benefit-risk and risk-risk tradeoff preferences in health and health care that could provide a basis for enriching the evidence base on risk preferences and providing support for benefits-transfer applications.
- Discounting does not correctly account for the effect of time on VSL. The SAB recommends that EPA use a more correct construct such as the value of statistical life-years lost rather than the present value of a future statistical death.

3.1.4. Empirical Studies

Charge Question 2. Please comment on whether relevant empirical studies in the stated preference and hedonic wage literatures are adequately captured in the White Paper. If additional studies should be included in the white Paper please provide citations.

The SAB was asked to comment on whether relevant empirical studies in the stated preference and hedonic wage literatures are adequately captured in the White Paper. The SAB finds that there has been a lack of significant growth in the VSL literature since the last consideration of this topic by the SAB in 2011. Therefore, the EPA may need to commission more studies or create other incentives for new studies in order to improve the prospect for a deeper literature to support future reviews of VSL. The SAB suggests that the EPA consider the following additional VSL studies: Ashenfelter and Greenstone (2004); Davis (2004); Deleire, Khan, and Timmins (2013); and Viscusi and Gentry (2015). However, no firm recommendations are provided on how these studies might be incorporated in the White Paper, if at all. The SAB also suggests that the EPA consider hedonic studies other than those related to hedonic wage rates.

In considering whether relevant studies are adequately captured in the White Paper, it is important to recognize a number of limitations related to the scope of hedonic wage studies, particularly in relation to forms of sampling bias and the ability of these studies to provide a nationally representative estimate in the absence of assumptions needed to extrapolate from subpopulations included in published studies to a broad national population. In particular, as previously indicated, hedonic wage studies exclude non-workers, so the EPA should address the implications of using studies that fail to address individuals' choices of whether or not to work, rather than a near-exclusive focus on valuation derived from choice among different jobs with different risk levels. The SAB suggests that the EPA consider using hedonic wage studies that apply data other than the CFOI data, while acknowledging concerns that studies based on survey data may be subject to non-response biases.

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1 The SAB also provides specific recommendations concerning clarification of the study selection process
2 and potential limitations of studies used in the White Paper. The White Paper should contain more detail
3 or information, likely in appendices, to allow readers to assess how the reliance on published studies,
4 particularly other meta-analyses (including studies that drew from international data), might lead to
5 results that differ due to publication bias, lags in publication, or other concerns. Additional information
6 is needed in the White Paper to more clearly indicate the types of studies, other than hedonic wage or
7 stated preferences that were available for use but eliminated by screening criteria. The SAB notes that
8 existing meta-analysis studies might provide insight into the foundation for maintaining or altering study
9 screening criteria.

10
11 *Key Recommendations*

- 12
- 13 • The EPA should consider commissioning more studies or creating other incentives for new studies in
14 order to improve the prospect for a deeper literature to support future reviews of VSL.
- 15
- 16 • EPA should consider including the following additional VSL studies in the White Paper: Ashenfelter
17 and Greenstone (2004); Davis (2004); Deleire, Khan, and Timmins (2013); and Viscusi and Gentry
18 (2015).
- 19
- 20 • In the White Paper the EPA should address limitations of hedonic wage studies, particularly in
21 relation to forms of sampling bias and the ability of these studies to provide a nationally
22 representative estimate in the absence of assumptions needed to extrapolate from subpopulations
23 included in published studies to a broad national population.
- 24
- 25 • The White Paper should contain more detail or information to allow readers to assess how the
26 reliance on published studies, particularly other meta-analyses (including studies that drew from
27 international data), might lead to results that differ due to publication bias, lags in publication, or
28 other concerns <<*Chair’s note: a sentence could be added to suggest how EPA should do this.*>>
- 29
- 30 • The White Paper should more clearly indicate the types of studies, other than hedonic wage or stated
31 preferences that were available for use but eliminated by screening criteria.
- 32

33 **3.1.5. Population Weighting in EPA’s Analysis**

34
35 *Charge Question 3. Some estimates in the meta-analysis dataset in the White Paper are*
36 *constructed by weighting subpopulation-specific estimates within a study in order to*
37 *approximate an estimate for the general population. The specific weights used are described in*
38 *Appendix B of the White Paper. Please comment on whether the population-weighting approach*
39 *used in the White Paper is appropriate and scientifically sound.*
40

41 The SAB was asked to comment on whether the population weighting approach used in the White Paper
42 to approximate a VSL estimate for the general population is appropriate and scientifically sound. EPA’s
43 study screening criteria include selection of studies that provide a national level representation of
44 general U.S. adult population. However, it is clear from the detailed notes in the White Paper (Appendix
45 B) on the selection and weighting of estimates from each study included in the meta-dataset that the
46 agency necessarily incorporated studies that met this criterion only “sufficiently” (i.e., some estimates

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1 were reported by subgroup and these were weighted to derive a population estimate). As a result, several
2 of the studies appear to omit data directly applicable to some portion of the U.S. adult population. For
3 example, hedonic wage studies appear to omit non-workers, which tends also to omit older individuals
4 above a standard that each study set. Other hedonic wage studies used selected specific age groups
5 within the workforce, rather than attempting to use data across the full spectrum of workers, for the
6 purposes of the authors of published studies.

7
8 *General Comments on the EPA's Weighting Approach*

9
10 The SAB previously recommended that the EPA select studies that are representative of populations
11 affected by EPA regulations (EPA SAB 2011). Given the limited VSL literature, the SAB recognizes the
12 need to develop a weighting approach in order to use subpopulation estimates of VSL in the EPA's
13 analysis. However, the White Paper should provide additional explanation of how weighting was
14 actually done and how the studies were brought together for the aggregate estimate. In particular, the
15 following issues should be addressed.

- 16
17 1. EPA's approach to weighting, in many cases, focused on deriving an estimated mean. The White
18 Paper should provide a more detailed explanation of how weighting procedures would affect
19 estimates of standard errors.
- 20
21 2. Weighting by population shares is common but may not cover all of the potential sources of
22 selection bias, particularly for survey-based studies. The White Paper should more explicitly
23 address the implications of selection bias.
- 24
25 3. Weighting approaches should to give much greater consideration to details of the specific studies
26 being weighted. Population weighting and benefit-transfer weighting may involve different
27 principles and relevance.
- 28
29 4. As previously mentioned, several of the studies do not provide representation across all possible
30 groups (age, income, employment, ethnicity, agricultural workers, etc.) that necessarily compose
31 a truly representative sample. The implications of this should be discussed in the White Paper.
- 32
33 5. Weights should be tied to the time period of the original study, at least for the development of a
34 representative estimate supported by that study, while aggregating available estimates across
35 studies to obtain an overall estimate for 2013. This raises questions of whether weights should
36 correspond to the sample the study is intended to represent or to the full U.S. population.
- 37
38 6. Weighting to adjust for income differences in the populations (or time periods) in individual
39 studies should be done after determining the estimates to be drawn from a particular study time
40 period. Income adjustments should be addressed in the process of aggregating across studies to
41 derive an estimate for a representative population. In this regard, there should be an explanation
42 in the White Paper of how Hicksian and Marshallian measures of VSL should be aggregated
43 with a consistent measure of income to account for income effects. <<*Chair's note: it would be*
44 *helpful to provide a method and citation.*>>

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1 *Specific Comments on the Weighting of Subpopulation Estimates*

2
3 The SAB provides specific comments on the manner in which the weighting of particular estimates was
4 conducted in the White Paper analysis to accomplish both the benefit-transfer purpose and the
5 aggregation purpose in supporting the VSL estimate for a representative population.
6

7 There are two sets of weights that affect the estimates in the White Paper. The set of weights described
8 in the body of the White Paper concerns the weights applied to the various summary statistics describing
9 VSL estimates from each study. The second set of weights is discussed primarily in Appendix B of
10 White Paper. It appears that the process discussed in Appendix B was not used in all studies. The first
11 mention of these weights is on page 50 of the White Paper and relates to the Cameron, DeShazo, and
12 Johnson (2010) study where the 28 estimates reported in Tables 4 and 5 of that study were summarized.
13 These estimates are distinguished based on number of children, respondents' gender, age, and marital
14 status. The discussion in the White Paper suggests that the 2010 U.S. population Census was used to
15 develop a weighted average of the 28 estimates. However, the SAB notes that the Cameron–DeShazo
16 survey was conducted in December 2002 and questions why the EPA did not use the 2000 Census to
17 develop the weighted average. The SAB also notes that the discussion in the background material for the
18 Cameron–DeShazo research indicates that the Knowledge Networks Panel used for the research was
19 representative of the 2000 census. Therefore, Knowledge Network weights could also have been used.
20

21 In addition, the SAB finds that clarification of the weighting process is needed with regard to the
22 following specific issues.
23

- 24 1. Some stated preference surveys used in the White Paper are based on samples but do not report
25 averages for subpopulations. It is not clear whether this is the reason why no weights were
26 applied in these cases.
27
- 28 2. Estimates from the Cameron, DeShazo, and Stiffler (2013) study used in the White Paper were
29 also based on the 2002 samples. Again, 2010 weights were used but the demographic allocation
30 was different. It is not clear whether the weights reconciled since it appears the second set would
31 be an aggregate of the first.
32
- 33 3. The Cameron and DeShazo (2013) study is again based on the same 2002 sample. The weighting
34 approach described on page 55 of the White Paper should be clarified. It notes that “The first
35 four estimates were weighted with each of the last five estimates such that six estimates were
36 used to calculate each weighted average.”
37
- 38 4. The weighting process is more complex for the hedonic wage studies. For the Viscusi and Aldy
39 (2007) study, VSL measures were constructed for each of 5 age groups. Although separate
40 hedonic wage models were estimated for 1998, the weights appear to be for 2013 for the entire
41 population. No adjustment was made to account for the difference between those who are
42 working and those who are not for a variety of reasons. As a result, in this case the weights
43 appear not only to be for the wrong year but the wrong population. This approach mixes a benefit
44 transfer issue (assuming non-workers have the same VSL as workers) with the construction of a
45 population mean based on a sample. The SAB has similar concerns about the EPA's weighting
46 of the Aldy and Viscusi (2008) estimates and the weighting of any of the other hedonic wage

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1 estimates based on sub-populations.

2
3 *Improving the Population Weighting Approach*

4
5 To improve the population weighting approach, future work could be undertaken to investigate the
6 possibility of developing a more complex set of subpopulation weights that build upon what is known
7 about the subpopulations covered in each of the available studies (whether currently included in analysis
8 or not). This analysis would eliminate the need for the screening criterion that studies necessarily
9 provide a foundation, on their own, of a population-weighted estimate of VSL. The analysis would mix
10 benefit-transfer and statistical benefit transfer in a more comprehensive, potentially more consistent way
11 and enable the use of a wider spectrum of available studies to derive VSL estimates for subpopulations.
12 Meta-regressions over VSL estimates drawn from a larger set of studies, each of which might focus on
13 subpopulations, could be conducted to develop a function that would allow adjustment for
14 representativeness of whole population. This approach could also be used to identify studies that appear
15 to offer outliers in estimation, and then further consider whether there is reason to believe those studies
16 may nonetheless offer valid insight to a portion of the distribution of values that may not be available
17 from other studies. Such a meta-analysis would include statistical controls for methodological choices of
18 the authors of studies

19
20 An investigation of the feasibility of developing such an approach would involve consideration of the
21 following questions:

- 22
23 1. Is it feasible to develop a weighting approach that builds upon multiple studies to improve
24 estimation of VSL specific to many subpopulations of the U.S. and then aggregate such sub-
25 population estimates to reach an improved, broadly representative estimate?
26
27 2. Would such a process be aided by including information from scientifically sound studies that
28 focused on a narrower group (a specific sub-population), rather than setting the criteria for the
29 included studies to arise from a broadly representative sample?
30

31 The SAB finds that such an approach could offer the advantage of including more information from
32 more studies that may meet appropriate screening criteria while relaxing the requirement for a national
33 focus. Although a new and more complex approach could potentially reduce transparency, it could also
34 improve confidence in a resulting representative estimate which would be based on a wider foundation
35 of literature. This could raise confidence in benefit-cost analysis sufficiently to justify the complexity
36 involved.

37
38 *Key Recommendations*

- 39
40 • The White Paper should provide further explanation of how the weighting of subpopulation-specific
41 estimates was actually done and how the studies were brought together for the aggregate estimate. In
42 particular, the White Paper should:
43 – Provide a more detailed explanation of how weighting procedures would affect estimates of
44 standard errors.
45 – More explicitly address the implications of selection bias.
46 – Give much greater consideration to details of the specific studies being weighted.

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- 1 – Tie weights to the time period of the original study (at least for the development of a
2 representative estimate supported by the original study) while aggregating available estimates
3 across studies to obtain an overall estimate for 2013.
- 4 – Adjust for income differences in the populations (or time-periods) in individual studies after
5 determining the estimates to be drawn from a particular study-time-period (income
6 adjustments should then be addressed in the process of aggregating across studies to an
7 estimate for a representative population).
- 8 – Explain how Hicksian and Marshallian measures of VSL should be aggregated with a
9 consistent measure of income to account for income effects.

- 10
- 11 • The weighting process used for specific studies listed in Appendix B of the White Paper should
12 clarified.
- 13
- 14 • EPA should consider undertaking future work to investigate the possibility of developing a more
15 complex set of subpopulation weights that build upon what is known about the subpopulations
16 covered in each of the available studies (whether currently included in the White Paper or not).
- 17

18 **3.1.6. Estimation of Standard Errors**

19

20 *Charge Question 4. In some cases EPA estimated standard errors in the White Paper using*
21 *information within studies or provided by the study authors, as described in Appendix B. Please*
22 *comment on whether the methods used in the White Paper to estimate standard errors when such*
23 *information was not readily available are appropriate and scientifically sound.*
24

25 There are two major aspects of Charge Question 4 that must be addressed. One is related to how the
26 standard error (se) of the VSL is calculated in situations when the standard error is not reported in the
27 original study. In the White Paper, the EPA attempts to estimate the standard errors of the VSL when the
28 original study does not report it. The SAB was asked to comment on whether the methods used to
29 estimate the standard errors are appropriate and scientifically sound. The second, perhaps more
30 important, aspect of the charge question is related the methods the EPA used to estimate standard errors
31 for the overall VSL estimates in the White Paper.

32 *Calculation of the Standard Error of the VSL when it is Not Reported in the Original Study*

33

34

35 The White Paper fails to provide detailed information about how the standard error (se) of the VSL is
36 calculated in situations where one is not reported in the original study. The SAB recommends that the
37 White Paper provide a detailed description of the method, including the formula used for calculating the
38 standard error for each study where the standard error of VSL is not reported. In particular, the SAB
39 recommends that the EPA provide the following additional information in the White Paper.

- 40
- 41 1. For several stated preference studies, including Corso, Hammitt, and Graham (2001) and
42 Viscusi, Huber, and Bell (2014), the White Paper states that standard errors for the reported VSL
43 estimates were calculated using the confidence intervals reported by the authors. However, the
44 White Paper does not provide details about how this was done. Under some assumptions, one
45 can calculate the standard error of a VSL estimates (\widehat{VSL}) based on its 95% confidence interval
46 using the following formula:

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$$se(\widehat{VSL}) = \frac{\overline{VSL} - \widehat{VSL}}{t_{0.025}(n)} \quad (1)$$

where \overline{VSL} is the upper bound of the 95% confidence intervals reported by the authors, and $t_{0.025}(n)$ is read off as the 2.5 percent point of the t -distribution with n degree of freedom. The White Paper should present the formula it uses to translate confidence interval to standard error estimates.

2. For the Cameron, DeShazo, and Stiffler (2013) study, the White Paper states that “[w]e approximated the standard errors of the weighted VSL estimates the graphical information provided in an on-line appendix referenced in Figure 3 of the original study. We enlarged each graphic to visually identify an approximate point estimate for the 5th and 95th percentiles associated with each WTP estimate. We then used this information to calculate a standard error for each estimate.” The SAB recommends that the EPA contact the authors to obtain the data instead of visually identifying an approximate point estimate for the 5th and 95th percentiles.
3. In several cases, the White Paper calculated standard errors for mean willingness to pay when the original study reported variance for median willingness to pay. The SAB recommends that in the White Paper the EPA provide a detailed explanation of how this was done.
4. For hedonic wage studies, the White Paper notes that the standard error of the VSL is calculated “based on the standard error of the risk coefficient alone.” However, the exact formula used is not provided. The SAB recommends that EPA include this information in the White Paper. If the study provides the average wage information, then there is sufficient information available to accurately calculate the standard error of the VSL. Specifically, assuming a log linear specification and that each worker works 50 weeks per year (i.e., treating this as a constant) for average wage \bar{w} , let $\hat{\beta}$ represent the estimated coefficient on the occupational fatality risk variable (i.e., the estimate of the true parameter β) and $se(\hat{\beta})$ its standard error. Assume risk is measured as the number of fatalities each year per 10,000 workers in the occupation-industry category. The estimated VSL is then given by (Aldy and Viscusi 2008):

$$\widehat{VSL} = 10,000(50)(\hat{\beta})(\bar{w}) = 50,000\hat{\beta}\bar{w}. \quad (2)$$

This equation normalizes the VSL estimate to an annual basis by assumption of a 50-week work-year and by accounting for the units of the mortality risk variable. If the sample mean of wage provides an accurate estimate of the average wage \bar{w} , the standard error of the VSL is given by:

$$se(\widehat{VSL}) = 50,000 \bar{w} se(\hat{\beta}).$$

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1 On the other hand, if the sample mean of wage does not provide an accurate estimate of the
2 average wage \bar{w} , and the original study treats the average wage estimate \bar{w} as a random variable
3 and provides a standard error estimate for \bar{w} ,¹ the standard error of the VSL is given by:²
4

$$5 \quad se(\widehat{VSL}) = 50,000 \sqrt{\left\{ \left[se(\hat{\beta})^2 se(\bar{w})^2 + E(\hat{\beta})^2 se(\bar{w})^2 + E(\bar{w})^2 se(\hat{\beta})^2 \right] \right\}}.$$

6
7 *Methods for Estimating the Overall Standard Errors for the VSL*
8

9 It is extremely important to provide accurate standard error estimates for the VSLs because standard
10 errors are used to select the “preferred” model and the non-parametric estimate of the VSL. The SAB
11 has reviewed the methods used in the White Paper to estimate the standard errors for the VSL estimates
12 and provides the following findings.
13

- 14 1. Given the important role that standard errors play, the SAB finds that the White Paper fails to
15 provide detailed information about how standard errors of VSLs are estimated. In fact, the White
16 Paper includes only two short paragraphs to discuss the methods used to estimate the standard
17 errors for the non-parametric VSL estimates (section 4.1.1) and does not discuss the methods
18 used to estimate the standard errors for the parametric VSL estimates at all.
19
- 20 2. The SAB finds that there are alternative, theoretically better, approaches (discussed below) to
21 estimate standard errors for the overall VSL estimates.
22
- 23 3. For the nonparametric approaches, the White Paper suggests five approaches/weighting methods
24 for estimating the VSL. For each approach, the white paper uses a bootstrap method to estimate
25 the standard errors of VSLs. The SAB finds that, because the discussion of the bootstrap
26 methods is so brief, it is unclear how the bootstrap approach is implemented. For example, the
27 paper states that “[t]o maintain the within-group correlation structure among the observations,
28 we randomly drew I sets of groups with replacement from the primary sample of grouped
29 observations. We did not re-sample observations below the top (group) level (Davison and
30 Hinkley 1997 p 100-101, Ren *et al.* 2010).” (p. 25). It is not clear how each I set of groups was
31 drawn and why re-sample observations below the top level were not re-sampled. In fact, the
32 meaning of “group/data sample” is unclear. In footnote 11 on page 20, the White Paper states
33 that “Hammitt and Graham (1999) and Corso, Hammitt, and Graham (2001) each examined 4
34 samples.” However, when looking at the last column of Table 6 on page 17, it appears that
35 Hammitt and Graham (1999) examined only one sample and Corso, Hammitt, and Graham
36 (2001) examined three samples. It is important to provide a clear definition of groups.
37
- 38 4. The White Paper uses a bootstrap approach to estimate standard errors for non-parametric VSL
39 estimates. The SAB finds that there are conceptual problems with this approach. When the
40 bootstrap approach is used, it seems that the estimated standard error reflects the variance of

¹ It should be noted that the sample standard deviation of wage might not provide a good estimate of how the mean wage estimate \bar{w} deviates from the real average wage.

² The calculation assumes β and w are independent random variables makes use of the following formulas. The variance of the product of a constant a and a random variable X is given by $a^2 var(X)$. The variance of the product of two independent random variables X and Y is given by $var(X)var(Y) + var(X)[E(Y)]^2 + var(Y)[E(X)]^2$.

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VSL estimates among the sample; it does not reflect the deviation of the VSL estimate from the true VSL. Conceptually, the accuracy of VSL estimates from individual studies used in the White Paper should affect the accuracy of the VSL estimates in the White Paper. This means that standard errors of individual VSL estimates should affect the standard error of the overall VSL estimate. However, the bootstrap estimates of the standard error do not use the standard error estimates from the individual studies at all.

5. The SAB finds that there is an alternative, perhaps theoretically better way to calculate standard errors for each non-parametric VSL estimator. Specifically, by definition, the standard error of a non-parametric VSL estimate equals

$$se(\widehat{VSL}) = [E(\hat{y} - E\hat{y})^2]^{1/2} = \left[E \left(\sum_{i=1}^I \sum_{j=1}^{m_i} w_{ij} (y_{ij} - Ey_{ij}) \right)^2 \right]^{1/2}$$
$$= \left[\sum_{i=1}^I \sum_{j=1}^{m_i} w_{ij}^2 (\sigma_{\eta}^2 + \sigma_{\mu}^2 + se_{ij}^2) \right]^{1/2} \quad (3)$$

Thus, once σ_{η}^2 , σ_{μ}^2 , and se_{ij}^2 are estimated, one can use the above formula to estimate the standard error of the VSL estimate directly. The SAB recognizes the challenges in estimating σ_{η}^2 and σ_{μ}^2 , but the proposed approach has three main advantages: (1) it is based on theory, (2) it is consistent with the weighting strategy used, and (3) it uses the standard error estimates from individual studies.

6. The SAB finds that the White Paper does not currently provide any discussion about the approach used to estimate the standard error of VSL estimates for the hedonic wage approach. It is assumed that the standard error of β_0 from the hedonic wage equation regression is used as the standard error of the VSL estimate. Again, it seems that the standard error of β_0 reflects the variance of VSL estimates among the sample; it does not reflect the deviation of the VSL estimate from the true VSL. Alternatively, because the hedonic wage regression provides estimates of σ_{η}^2 and σ_{μ}^2 , one can calculate the standard error of the VSL estimate by using equation (3) above.

Key Recommendations

- The white paper fails to provide detailed information about how the standard error of the VSL is calculated in situations where one is not reported in the original study. The SAB recommends that the White Paper provide a detailed description of the method, including the formula used for calculating the standard error for each study where the standard error of VSL is not reported.
- The SAB proposes an alternative, perhaps theoretically better, way to calculate standard errors for each non-parametric VSL estimator.

1 **3.2. White Paper Analysis**

2
3 **3.2.1. Overall Methodology for Analyzing the Data**

4
5 *Charge Question 5. Please comment on whether the methodology used in the White Paper to*
6 *analyze the data represents an appropriate and scientifically sound application of meta-analytic*
7 *methods to derive generally applicable VSL estimates for environmental policy analysis.*
8

9 The SAB finds that the meta-analytic methods used in the White Paper to analyze VSL estimates from
10 the literature are, for the most part, scientifically sound and consistent with standard and accepted
11 practices for conducting meta-analyses. To reinforce this conclusion it would be helpful for the White
12 Paper to be more explicit about what these accepted practices are and how they are applied. This could
13 be accomplished in several ways.

- 14
- 15 1. Several papers have proposed general steps, guidelines, and/or recommendations for conducting
16 meta-analysis. The most relevant paper is Nelson and Kennedy (2009). This paper is referenced
17 in the White Paper, but on a narrower issue. The White Paper would be strengthened by
18 organizing the discussion around (or least referencing) these types of best practice guidelines.
19 The White Paper does this to a limited extent with the PRISMA (Preferred Reporting Items for
20 Systematic Reviews and Meta-Analyses) framework (Moher et al. 2009), but this really only
21 applies to the study selection step.
22
 - 23 2. The non-parametric statistical methods used in the EPA’s analysis include approaches
24 (“sampling error” and “total error” variance weighted mean) that are fundamentally similar to
25 methods typically referred to in the meta-analysis literature as “fixed effect size (FES)” and
26 “random effect size (RES)” methods.³ Using, or least referring to, these labels, and describing
27 how the methods used in the White Paper depart from these more standard practices, would help
28 strengthen the presentation in the paper by tying it to the broader literature on meta-analysis.
29 Also, when applying and comparing these nonparametric meta-analytic approaches, standard
30 tests of homogeneity across groups (Q-tests) are generally recommended. These types of tests
31 should be discussed and reported in the White Paper.
32

33 One of the principal best practice guidelines suggested by Nelson and Kennedy (2009) and supported by
34 the SAB is to “ensure that the effect-size measures from the primary studies are all measuring the same
35 thing.” The White Paper could better address this recommended practice in several ways.

- 36 1. The White Paper could provide more detail about each of the primary studies and the selected
37 value estimates in a way that reinforces the direct comparability of the objects/commodities
38 being valued. For example, it is very important that the temporal dimensions of the willingness
39 to pay estimates be directly comparable (i.e., that they all measure or are converted to annual
40 willingness to pay estimates for annual risk reductions). In the White Paper more attention
41 should be given to describing the temporal features used in each study.
42

³ The RES method is mentioned in the White Paper, but only in reference to the parametric/meta-regression approach.

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- 1 2. Where there are differences in the effect size measures across studies or value estimates, the
2 White Paper should consider, discuss, and as appropriate include, adjustments to make the
3 measures more comparable. For example, as previously discussed, the stated preference studies
4 provide Hicksian value measures and the hedonic studies provide Marshallian measures. The
5 SAB recommends that EPA consider and describe the types of assumptions (e.g., preference
6 structure) that would be needed to convert the Marshallian to Hicksian measures and evaluate the
7 advantages or limitations of making this type of adjustment.
8
- 9 3. The SAB finds that there is insufficient evidence in the income elasticity of VSL literature to
10 adjust the VSL values from different studies to account for differences in income. Therefore, the
11 SAB recommends that both the non-parametric and parametric analyses be conducted without
12 this direct adjustment to VSL. The parametric meta-regression analysis should include
13 specifications with an income measure as an explanatory variable. This income measure should
14 be selected to approximate as closely as possible the average disposable household income of the
15 sample used in the primary study.

16 Another best practice guideline is to explicitly address and account for heterogeneity in the variance of
17 the effect size estimates. The White Paper does this in several ways, including the use of “sample size
18 weighted mean” in the non-parametric analysis. Sample size weighting has often been used in meta-
19 analyses of willingness to pay estimates. Typically it is used as proxy for variance when variance
20 estimates are not available. However, in this application variance estimates are available; therefore, it is
21 not clear what is gained by including a sample size weighted approach. Its inclusion should be better
22 justified.

23 *Key Recommendations*

- 24 • The White Paper should more explicitly discuss the standard and accepted practices for conducting
25 meta-analysis, e.g., Nelson and Kennedy (2009), and how they have been applied. In particular:
26
 - 27 – The White Paper should refer to fixed effect size (FES)” and “random effect size (RES)”
28 methods and describe how the methods used in the White Paper depart from these standard
29 practices,
 - 30 – When applying and comparing nonparametric meta-analytic approaches, standard tests of
31 homogeneity across groups (Q-tests) are generally recommended. These types of tests should
32 be discussed and reported in the White Paper.
- 33
- 34 • The White Paper should provide more detail about each of the primary studies and the selected value
35 estimates in a way that reinforces the direct comparability of the objects/commodities being valued.
36
- 37 • Where there are differences in the effect size measures across studies or value estimates, the White
38 Paper should consider, discuss, and as appropriate include, adjustments to make the measures more
39 comparable.
40
- 41 • Both the non-parametric and parametric analyses should be conducted without adjusting the VSL
42 values from the different studies to account for differences in income. However, the parametric

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1 meta-regression analysis should include specifications with an income measure as an explanatory
2 variable.

- 3
4 • The use of “sample size weighted mean” in the non-parametric analysis should be better justified.
5

6 **3.2.2. Grouping Samples for Analysis**
7

8 *Charge Question 6. The White Paper classifies estimates into independent samples, also called*
9 *groups, as described in Section 4. Estimates from some hedonic wage studies that use the same*
10 *or very similar worker samples are grouped together for the analysis. Similarly, some of the*
11 *stated preference estimates using the same sample are grouped together. Please comment on*
12 *whether this methodology represents an appropriate and scientifically sound approach for*
13 *accounting for potential correlation of results that rely on the same underlying data.*
14

15 The SAB agrees that that it makes sense to group studies in the White Paper based on similar samples to
16 account for the lack of independence in estimates constructed from the samples. However, additional
17 detail should be included in the White Paper to clarify how the grouping decisions were made. A column
18 should be added to Table 6 of the White Paper to provide information more clearly identifying the
19 composition of the various study groups.
20

21 The SAB also recommends that the EPA conduct additional analysis to check the robustness of the
22 results to different plausible group definitions. Specifically, the SAB recommends that the EPA: (1)
23 explore the sensitivity of results to alternative group assignments; (2) use the influence analysis to
24 examine the robustness of the results to individually excluding each group; and identify; and (3) identify
25 the primary estimate from each study and re-estimate the meta-regression using only primary estimates.
26

27 *Key Recommendations*
28

- 29 • Additional detail should be included in the White Paper to clarify how studies were grouped for the
30 analysis. A column in Table 6 should provide information on the composition of various study
31 groups.
32
- 33 • EPA should check the robustness of the results to different plausible study group definitions. This
34 robustness check should include:
35 – Exploring the sensitivity of results to alternative group assignments.
36 – Using the influence analysis to examine the robustness of results to excluding each group.
37 – Identifying the primary estimate from each study and re-estimating the meta-regression
38 using only primary estimates.
39

40 **3.2.3. Addressing Sampling and Non-Sampling Errors**
41

42 *Charge Question 7. Section 4.1 of the White Paper presents an expression that characterizes*
43 *optimal weights that account for sampling and non-sampling errors, a framework that guides*
44 *EPA’s approach. Please comment on whether this is an appropriate and scientifically sound*
45 *approach for addressing sampling and non-sampling errors.*
46

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1 Additional information is needed to fully address this charge question. The SAB finds that derivation of
2 the expression characterizing optimal weights that account for sampling and non-sampling errors should
3 be more transparent in the White Paper. Therefore, the SAB recommends including in the text of the
4 White Paper (or in an appendix) the various steps required to derive equation (4) in Section 4.1.
5 Citations establishing the validity of the basic approach, if not the literal equation, should also be
6 included. Regarding use of the weights, clarification of and justifications for the assumptions regarding
7 the error components should be included. Finally, the white paper emphasizes the efficiency of the
8 various estimators presented. The SAB suggests that transparency should also be included as a criterion
9 for selecting the estimator.

10
11 *Key Recommendations*

- 12
- 13 • The various steps required to derive equation (4) in Section 4.1 of the White Paper should be
14 included in the text or in an appendix. Citations establishing the validity of the basic approach, if not
15 the literal equation, should be included.
- 16
- 17 • With regard to the use of weights, clarification of and justifications for the assumptions concerning
18 the error components should be included in the White Paper.
- 19
- 20 • Transparency should be included in the White Paper as a criterion for selecting an estimator.
- 21

22 **3.2.4. Non-parametric and Parametric Approaches for Estimating Value of Statistical Life**

23
24 *Charge Question 8. The analysis in the White Paper adopts both non-parametric and parametric*
25 *approaches (sections 4.1 and 4.2, respectively). Please comment on whether these approaches*
26 *span a reasonable range of appropriate, scientifically sound, and defensible approaches to*
27 *estimating a broadly applicable VSL for environmental policy and whether there are other*
28 *methods that are more appropriate than those used in the White Paper.*
29

30 The EPA White Paper adopts both non-parametric and parametric approaches to estimate a VSL. The
31 SAB finds that some additional information is needed in the White Paper to explain the use of these
32 approaches. The SAB recommends that the EPA provide citations for the non-parametric approaches
33 (estimators 1-5 on pages 22-23 of the White Paper) and better justification for the methods in terms of
34 the specific application. Specifically, the justification should explain why these methods are relevant to
35 finding the central tendency of VSL estimates from studies that in most cases report multiple estimates.
36 Some discussion of the conceptual merits and data requirements of each method is needed. The SAB
37 notes that estimator 3 is described in the text on meta-analysis by Hunter and Schmidt (2004) and
38 estimator 4 is described in the text on meta-analysis by Hedges and Olkin (1985) and implemented in a
39 recent meta-analysis by Hsiang et al. (2013).

40 The SAB agrees with the EPA's conclusion that the mean of group means estimator is the preferred non-
41 parametric method. The EPA's argument is that it has the smallest estimated standard error (p. 32 of the
42 White Paper). The SAB recommends that the EPA also justify use of the mean of group means estimator
43 on the grounds that it avoids giving more weight to papers that report more estimates. It is not clear why
44 there is so much variation across papers in the number of reported estimates. This may be a result of
45 idiosyncratic factors (e.g., stylistic choices by authors, requests by referees for robustness checks) and,
46 as such, it is better to give equal weight to groups of estimates.

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1 Although the SAB supports the EPA’s focus on the mean of group means estimator, it is recommended
2 that the agency explore the use of an alternative non-parametric method that incorporates information on
3 sampling error variance from each study. This estimator is a blend of approaches 2 and 4 and would be
4 computed as follows:

$$\hat{y} = \frac{1}{I} \sum_{i=1}^I \frac{1}{\sum_{j=1}^{m_i} se_{ij}^{-2}} \sum_{j=1}^{m_i} se_{ij}^{-2} y_{ij} \quad (4)$$

6 The estimator computes the mean of sampling error variance weighted group means.

7 For the parametric estimator, the SAB recommends that the EPA provide better explanation of and
8 justification for the included control variables. Some of this discussion is found in section 6.1 of the
9 White Paper, but is better placed in section 4.2. The SAB recommends that, if feasible, the EPA should
10 include additional controls in the parametric model. One suggestion is to include dummy variables for
11 whether given researchers are co-authors.

12 There is evidence of an upward time trend in inflation-adjusted VSL estimates, whether or not the
13 estimates are further adjusted for income differences over time. The parametric model includes a control
14 for this time trend but the non-parametric estimators does not. The current document does not explain
15 what the time variable in the parametric model was intended to capture. It could reflect real changes in
16 preferences over time, changes in knowledge about health risks, or changes in valuation methodology.
17 The SAB recommends that the EPA be consistent in its treatment of the time trend. If it is controlled for
18 in the parametric model, it should be controlled for in the non-parametric models. However, it is not
19 clear how the time trend, if included, should be used in producing the final VSL estimate. The time
20 variable could be evaluated in the current year, the end of the data period, or the midpoint of the data
21 period. The first two approaches would place greater weight on more recent studies, which could be
22 appropriate if one believes that methodologies are improving over time. However, if one believes that
23 methodologies are getting better, estimates should simply be taken from the most recent study. More
24 generally, if one believes there are differences in quality over time, one should pick the study that
25 appears to be the best. Leaving the time trend out of the models would implicitly give equal weight to
26 estimates from different years. This approach might be preferred in the absence of strong beliefs about
27 the source of the time trend.

28
29 *Key Recommendations*

- 31 • Citations should be provided in the White Paper for the non-parametric approaches (estimators 1-5
32 on pages 22-23) and better justification should be provided for the methods in terms of the specific
33 application. Specifically the justification should explain why these methods are relevant to finding
34 the central tendency of VSL estimates from studies that in most cases report multiple estimates.
- 35
- 36 • EPA should justify use of the mean of group means estimator on the grounds that it avoids giving
37 more weight to papers that report more estimates.
- 38
- 39 • EPA should explore the use of an alternative non-parametric method that incorporates information
40 on sampling error variance from each study.
- 41
- 42 • For the parametric estimator, the SAB recommends that the EPA provide better explanation of and
43 justification for the included control variables.

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- EPA should be consistent in its treatment of the time trend time trend in VSL estimates. If it is controlled for in the parametric model, it should be controlled for in the non-parametric models.

3.3. White Paper Results

3.3.1. Proposed Estimates of Value of Statistical Life

Charge Question 9. The White Paper presents estimates using parametric and non-parametric models, pooled across stated preference and hedonic wage studies as well as balanced (i.e., equal weight to each study type), and weighted using different approaches. Of the range of estimates presented (see Section 4) the White Paper proposes the use of estimates from the following models:

- *Non-parametric model, balanced, mean of study mean*
- *Parametric, balanced*

Please comment on whether these proposed estimates represent reasonable and scientifically sound conclusions from the analyses in the White Paper and whether there is a different set (or sets) of results that are preferable based on the data and analysis in the White Paper.

The SAB finds that the proposed summary VSL measures (nonparametric balanced mean of the study mean and parametric balanced) are defensible estimates. As indicated in the response to Charge Question 8, the EPA should also consider using the non-parametric sampling error variance weighted group mean in place of the non-parametric mean of group means estimator. However, it is important to distinguish these estimates from those that have used weights to construct “general population” measures for the U.S. population. There are inconsistencies in the weights used across studies. For the estimates derived from the 2002 stated preference study designed by Cameron and DeShazo for a representative sample of U.S. households, the weights should be based on the Knowledge Network weights for the 2000 census not the 2010 census. For the hedonic wage studies, the weights appear to be based on 2013 information for the general population when the samples are for earlier years and are designed to represent populations of individuals who choose to work full time. In this case, weighting to derive a mean for the general population mixes a *benefit transfer* assumption with a *sample weighting* decision. The benefit transfer assumption involves assuming non-workers whether unemployed, retired or not participating for another reason have the same risk tradeoffs (VSL) as those working. This decision should be explicit and not “buried” in the weighting process. Although this may not cause a large effect, it is not possible to determine the size of the effect based on what is presented.

Adjustment of VSL estimates by an income elasticity of VSL and index of income growth (based on GDP per capita) does not seem appropriate. However, conversion of VSL to inflation adjusted dollars would be appropriate. “Building in” the income elasticity and growth assumptions as maintained hypotheses before constructing the mean mixes a benefit transfer decision with an adjustment for household income across different studies. More specifically, income adjustment could involve: (1) adjustment for differences in the income across different samples that could hypothetically alter the risk tradeoff; and (2) adjustment for changes in real income over the time period covered by the effects of a rule where assumptions about the growth of the income might be expected to raise all households

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1 income for the future date when the policy was implemented. This type of “income adjustment” would
2 be a part of the benefits transfer associated with modifying a unit value so it is consistent with the
3 economic conditions at the time the policy is assumed to affect mortality risks. It is different from an
4 adjustment conducted to a primary estimate before developing the mean estimates for VSL. At present,
5 the documentation of income adjustment in the white paper is not clear. Table 6 of the White Paper
6 refers to the use of an income elasticity of 0.7 but does not clearly discuss the income used in the two
7 adjustments. In addition the SAB notes that adjustment for income with the stated preference measures
8 would need to be different because these are derived from Hicksian welfare measures <<*Chair’s note:*
9 *can we provide a citation for methods that could be used for this kind of adjustment?*>>.

10
11 **Key Recommendations**

- 13 • The proposed summary VSL measures (nonparametric balanced mean of the study mean and
14 parametric balanced) are defensible estimates but the EPA should also consider using the non-
15 parametric sampling error variance weighted group mean in place of the non-parametric mean of
16 group means estimator.
- 18 • The documentation of income adjustment to VSL should be clarified in the White Paper. Adjustment
19 of VSL estimates by an income elasticity of VSL and index of income growth (based on GDP per
20 capita) does not seem appropriate. However, conversion of VSL to inflation adjusted dollars would
21 be appropriate.

22
23 **3.3.2. Influence Analysis**

24
25 *Charge Question 10. The results section of the White Paper concludes with an influence analysis.*
26 *Please comment on whether this analysis is a reasonable way to characterize the influence of*
27 *individual studies on the estimated VSLs, whether the results of the influence analysis suggest any*
28 *changes or modifications to the estimation approach, and whether it is important to include an*
29 *influence analysis.*

30
31 An influence analysis is important, especially given the implicit assumptions underlying the structure of
32 the non-sampling error related to groups. Some form of influence analysis is important for meta-analysis
33 in cases where there are few studies to consider, and therefore one or two individual studies might have
34 a substantial influence on the estimates. Influence analysis is most important to make sure that the
35 influence not skew the results in a single direction. For example, if there are two studies with +10% and
36 -10% influence the two studies are more or less balanced. Looking at the mean of group means in the
37 White Paper, the two most influential studies are Corso Hammitt and Graham (2001) at -13.8% and
38 Chestnut, Rowe, and Breffle (2012) at -11.1. Taken together, these studies nearly balance each other. In
39 contrast, for the maximum likelihood stated preference estimates, the Corso, Hammitt and Graham
40 (2001) at -22.8 % is well over two times more influential than the second most influential study, which
41 fortunately is of the opposite sign. Rather than dropping Corso, Hammitt and Graham (2001) altogether,
42 one might use a robust estimation technic that limits the influence of this observation. One possibility is
43 to adjust the weight on this study downward until it just balances the Alberini et al. (2004) study, or to
44 downweight all studies that are identified as relatively influential (perhaps studies that fall above the +/-

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1 10% influence range). This type of approach of down weighting highly influential observations has a
2 long history.

3
4 It would also be useful to consider the potential for using regression diagnostic indexes (Belsley et al.
5 1980; Cook and Weisberg 1982; Belsley 1991) for the parametric modeling of VSL. These statistics
6 allow analysts to consider whether specific observations were influential to individual coefficients in the
7 meta-regression function. They allow an assessment of whether the magnitude and significance of
8 individual coefficients was influenced by particular observations.⁴ Since these correspond to the specific
9 studies and models within a study, they could help in understanding how the group definition discussed
10 earlier influences the specific mean statistics proposed to construct a population level measure for the
11 mean VSL.

12
13 *Key Recommendations*

- 14
15 • Influence analysis of the maximum likelihood stated preference estimates indicates that Corso,
16 Hammitt and Graham (2001) at -22.8 is well over two times more influential than the second most
17 influential study. The EPA should consider using a robust estimation technique that limits the
18 influence of this observation.
19
20 • The EPA should consider the potential for using regression diagnostic indexes (Belsley et al. 1980;
21 Cook and Weisberg 1982; Belsley 1991) for the parametric modeling of VSL.
22

23 **3.4. Protocol for Future Revisions of Value of Statistical Life**

24
25 **3.4.1. Criteria for Inclusion and Exclusion of VSL Estimates in Future Analyses**

26
27 *Charge Question 11. In the previous SAB advisory report (U.S. EPA Science Advisory Board*
28 *2011), the SAB endorsed the idea of establishing a standardized protocol and regular schedule*
29 *for future updates to the Agency’s mortality risk valuation estimates. Please comment on*
30 *relevant statistical criteria for the inclusion of additional eligible estimates and/or the exclusion*
31 *of older estimates that could help inform the development of a standardized protocol for future*
32 *updates and the timing or frequency of those updates.*
33

34 The SAB provides general and specific recommendations on the development of a standardized protocol
35 for future updates and the timing or frequency of those updates.

36
37 *General Recommendations*

38
39 The SAB notes that the value of risk reduction for mortality (VRR), a term previously suggested by the
40 SAB as a replacement for VSL, is very likely the most important “benefit measure” used in EPA’s
41 benefit-cost analyses for policies related to mortality risk. The level of staff effort and other research

⁴ These are “old” references but can provide useful indexes of how specific observations influence results. The discussion of “short data” in chapter 7 in Belsley (1991) may be especially relevant to parametric models developing meta summaries with limited variation in the risk and/or income measures that are used to estimate income elasticities or scope effects.

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1 resources devoted to regular updating and refining VRR estimates should be commensurate with their
2 importance for policy evaluation.

3
4 Given the importance of VRR, high priority should be assigned to increasing the pool of high quality
5 studies to support the VRR meta-analysis. This is particularly important due to the small number of data
6 sets to support hedonic price estimates, and the relatively small number of stated preference studies
7 currently included in the meta-analysis. In addition to improving the precision of VRR estimates,
8 additional high quality studies could improve the ability to estimate other important characteristics of
9 VRR, such as possible time trends, income elasticities, variability over subpopulations, cancer
10 premiums, and other factors that are central to policy analysis.

11
12 In the immediate term, the EPA can expand the number of studies by considering whether useful
13 information can be extracted from a variety of studies previously excluded from VRR calculations.
14 Subject to caveats and recommendations detailed below, such studies might include those with samples
15 that are not representative of the national population, results from other economic studies of risk
16 preferences (e.g., transportation safety, risk-risk tradeoffs, etc.) and results from research outside of
17 traditional peer-reviewed journals. The SAB could provide guidance on which studies are appropriate,
18 and/or any additional steps necessary to ensure that studies are used in an appropriate manner.
19 Recommendations regarding these issues are detailed below.

20
21 In the long term, new high quality studies could be elicited by EPA using existing and new mechanisms.
22 For example, EPA should consider whether estimation of VRR and its various attributes (e.g., time
23 trends, etc.) should be a high priority topic for Science to Achieve Results (STAR) grants and
24 fellowships, EPA sponsored conferences, special issues of journals, and young researcher awards. The
25 EPA could even consider the feasibility of sponsoring its own refereed journal that focuses on analyses
26 of direct relevance to meeting the agency's needs.

27
28 The EPA might also obtain more general information about protocols for updating estimates from the
29 experience of other agencies that construct economic index numbers for policy. For example, the Bureau
30 of Labor Statistics (BLS) calculates the Consumer Price Index, based on a weighted set of prices to
31 calculate the cost of a "representative basket" of consumer goods and services. BLS updates the weights
32 periodically to account for new goods and for changes in quality of goods over time. The EPA could
33 learn from protocols used by BLS and other agencies for periodic updates.

34
35 *Statistical Criteria for the Inclusion of Additional Eligible Estimates and/or the Exclusion of Older*
36 *Estimates*

37
38 There should be a single set of criteria for determining which studies are of sufficient quality to be
39 included in the estimates of VRR. Therefore, the validity criteria for inclusion of additional studies and
40 exclusion of older studies should be the same as those to assess the estimates that are currently in use.
41 These criteria have been discussed in detail in the response to Charge Question 1a.

42
43 Similarly, the SAB recommends that the exclusion of older estimates be evaluated on a case-by-case
44 basis using the same validity criteria, rather than dropping studies simply based on their being dated, *per*
45 *se*. If there is strong evidence that risk preferences change over time, the SAB recommends developing
46 procedures to adjust older estimates that are otherwise judged to be valid, rather than dropping estimates

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1 simply because they are older. This is especially pertinent given the small number of studies upon which
2 current VRR estimates are based.

3
4 *Timing or Frequency of Updates*

5
6 The SAB finds that a 5-year interval of updating estimates is probably appropriate. More frequent
7 updating might be desirable, but based on experience in the past several years, there appear to be too few
8 new estimates each year to justify the time and expense involved in more frequent updating.

9
10 *Potential Sources of Information Outside of Peer-Reviewed Journals <<Chair’s note: this should be*
11 *discussed>>*

12
13 As previously indicated, increasing the number of high quality studies included in the meta-analysis is a
14 high priority. For this reason, the SAB has considered whether studies should be restricted to those that
15 are published in peer-reviewed literature.

16
17 The SAB recommends that the EPA not necessarily restrict studies to those published in peer-reviewed
18 journals, but rather that studies outside of the peer-reviewed journals should be considered for inclusion
19 following a transparent and rigorous peer review process. The SAB emphasizes that it is inadequate to
20 simply assert that a study was subject to peer review. Rather, a quality controlled peer review process
21 should be established. For example, EPA might ask the SAB to organize a process to review research
22 results outside of traditional peer reviewed journals, both to identify appropriate reviewers (possibly
23 including SAB members), and to determine whether or not studies that undergo peer review are judged
24 to “pass” the review process, and therefore qualify for inclusion.

25
26 Extending sources of information to research outside of peer-reviewed journals has the potential to
27 substantially increase the number of studies available to estimate VRR, and research papers outside of
28 peer-reviewed journals likely include high quality empirical analyses, even if they are not submitted for
29 publication in journals. A major challenge to relying only on publications in peer reviewed journals is
30 that economics journals rarely publish articles that contain routine empirical analyses without some sort
31 of innovation or other improvement in the state-of-the-art. As a consequence, many analyses could
32 provide satisfactory estimates of VRR, but may not be submitted to peer-reviewed journals, or may be
33 rejected for publication because they do not improve upon the state-of-the-art. This may be particularly
34 relevant for analyses carried out by consulting companies, for whom publication of research results in
35 peer-reviewed journals may or may not be of high priority.

36
37 *Information from Other Economic Studies of Risks*

38
39 The SAB recommends that the EPA consider whether useful information can be extracted from other
40 studies that could improve estimates of VRR and its characteristics (e.g., latency, morbidity). This might
41 include studies of risk-risk tradeoffs, hedonic analyses in addition to hedonic wage studies, risk studies
42 in the transportation safety literature, and possibly others. For example, EPA might consider using the
43 results of a risk-risk study that employed a stated preference approach, wherein respondents were asked
44 to choose whether to undergo treatment (e.g., a risky surgery) that has a stated risk of immediate
45 mortality versus a given risk of cancer, which involves stated risks of both long term morbidity and
46 subsequent mortality. EPA might also use the results of a study that asked respondents to choose

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1 whether to undergo treatment that has a stated risk of morbidity (e.g., paralysis, chronic pain, etc.)
2 versus foregoing treatment, in which case they face a stated mortality risk. These studies could
3 potentially be useful for calibrating differences in VRR across risks with differing degrees of latency,
4 morbidity, etc. (e.g., a possible cancer premium). These issues are particularly relevant given EPA's
5 focus on environmental risks, which often involve long latency periods, and where mortality is often
6 preceded by a significant period of morbidity.

7
8 The EPA should also consider whether useful information can be extracted from other categories of
9 studies, such as hedonic literature outside of hedonic wage studies, and possibly transportation safety
10 studies. For example, it may be possible to extract useful VRR information from hedonic studies of the
11 effects of air pollution on housing prices, although challenges may exist in isolating mortality and
12 morbidity effects from other effects, such as visibility. Estimates of VRR from transportation safety
13 studies might also be applicable VRR from environmental risks.

14
15 *Information from Studies with Non-National Samples*

16
17 Similarly, the SAB recommends that EPA not necessarily exclude studies simply because they are based
18 on non-national samples, as long as there is a broad set of studies that as a group is generally
19 representative of the nation as a whole. For example, EPA should consider studies based on
20 representative samples at the state and regional levels, as long as there is an adequate number of studies
21 using representative samples for a diverse set of states and/or regions. The SAB suggests that it probably
22 would not be appropriate to adopt estimates from studies based on narrow demographics, or a very small
23 geographic area (e.g., a single community) since they may not be representative.

24
25 If there are a reasonable number of studies at the state and regional levels, one could carry out
26 consistency checks to ensure that similar estimates result from national level studies and a set of state
27 and/or regional level studies. As previously indicated, in addition to improving the precision of VRR
28 estimates, increasing the number of high quality studies has the advantage of allowing improvements of
29 estimates of related measures, such as time trends, income elasticities, and variability over
30 subpopulations.

31
32 *Open Data Initiatives*

33
34 Another challenge in depending only on existing studies published in peer-reviewed journals for VRR
35 estimates is it that makes EPA dependent upon only those results that are reported in the publication, and
36 possibly additional information that can be obtained by contacting the authors. For example, some
37 studies report VRR estimates, but do not report associated standard errors or confidence intervals on
38 VRR, income elasticities, and estimates by sub-population. Additionally, different studies use different
39 statistical methods, control for different influences and otherwise use different procedures that are
40 difficult to control for after the fact.

41
42 The SAB recommends that the EPA consider a long term strategy of requiring that a more inclusive set
43 of research results, and even whole data sets, be made generally available for use by the research
44 community and by government agencies. Project Open Data (U.S. Office of Management and Budget
45 and U.S. Office of Science and Technology Policy 2016) provides an excellent framework for making
46 data available in order to improve the information obtained from available studies.

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1
2 It is becoming increasingly common practice for agencies and professional associations to develop open
3 data policies, which require or strongly encourage that data be made widely available to the research
4 community, to the extent feasible. For example, in May 2013 President Barack Obama issued an
5 Executive Order and an associated Open Data Policy for all federal agencies. The Office of Management
6 and Budget’s Open Government Directive creates a “presumption in favor of openness to the extent
7 permitted by law and subject to privacy, confidentiality, security, or other valid restrictions,” and
8 requires that agencies publish high-value data sets in an open format through Data.gov (The White
9 House 2016). Federal grants and contracts could require that data collected under EPA grants and
10 contracts require that data be published to Data.gov in standard format (U.S. General Services
11 Administration 2016). This is consistent with U.S. Office of Management and Budget (OMB) policy,
12 which established the principle that, where feasible, data be public, accessible, fully described, reusable,
13 complete, timely and managed post-release. Similar open data policies have been adopted by peer-
14 reviewed journals like *Science*, *Nature* and *PLOS*.

15
16 An open data policy would have the advantage of providing an opportunity to replicate research results,
17 to help improve quality control on reported estimates, and to go back after the fact to estimate
18 parameters of importance that are not reported in the original publication (e.g., VRR standard errors).
19 Additionally, data from multiple studies could be used to apply more refined estimation techniques, to
20 apply more comparable standards (e.g., explanatory variables) across studies, and to correct possible
21 biases in studies. For example, data collected in the immediate aftermath of a major event (e.g., the
22 Great Recession of 2007-2009) might not be representative of the long term. A single parameter
23 estimate from a study using pooled data from 2005-2010 might not be refined enough to adjust for
24 differences during the recession years. Access to the original data set could provide researchers with the
25 opportunity to correct for such influences.

26
27 More broadly, collecting primary data is expensive, and it is inefficient to expend large amounts of
28 funding to collect data for a single analysis and then exclude those data from being used for other
29 productive purposes. Indeed, a recent report has estimated that open data could add \$3 trillion to \$5
30 trillion in economic value to the global economy each year (Manyika et al. 2013). While the SAB has
31 not had an opportunity to review this particular study, it is clearly suggestive of the substantial social
32 value in making data more widely available to the research community.

33
34 At the same time, the SAB recognizes there are important challenges to making data sets publicly
35 available. For example, issues may arise with respect to confidentiality of survey respondents in some
36 data sets. Also, all data sets have important limitations that are often best known to those who originally
37 collected that data. In addition, many researchers will want to publish results from data sets prior to
38 making them public. However, the SAB finds that challenges associated with these issues can be
39 minimized by carefully considering data sharing policies and the important efficiencies in making data
40 publicly available. The SAB recommends that the EPA work in collaboration with other agencies and
41 professional associations to pursue reasonable and prudent actions to make data publically available.

42
43 *Routine Compilation of Existing Data Sets*

44
45 The EPA might also make an effort to routinely compile data from various key sources for regular use.
46 For example, the EPA might simplify periodic updating of hedonic wage estimates of VRR by creating

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1 an archive of wage data and perhaps other data from the U.S. Census Bureau’s demographic supplement
2 to the Current Population Survey, matched with data from the U.S. Bureau of Labor Statistics Census of
3 Fatal Occupational Injuries (CFOI) in standardized form, and perhaps other data sets. Once in place,
4 such a data archive would allow for consistent periodic updates of VRR at low cost, rather than waiting
5 for updated publications in the peer-reviewed literature. This approach also has the advantage of
6 providing a consistent methodology underlying hedonic wage estimates over time. EPA might create its
7 own data archive, or the compiled data might be published in existing data archives, such as Data.gov.
8

9 *Key Recommendations*

- 10
- 11 • The pool of high quality studies to support the VRR meta-analysis should be increased. To
12 accomplish this the EPA should:
 - 13 – Consider whether estimation of VRR and its various attributes (e.g., time trends, etc.) should
14 be a high priority topic for Science to Achieve Results (STAR) grants and fellowships, EPA
15 sponsored conferences, special issues of journals, and young researcher awards
 - 16 – Consider the feasibility of sponsoring its own refereed journal that focuses on analyses of
17 direct relevance to meeting the agency’s needs.
 - 18 – Obtain more general information about protocols for updating estimates from the experience
19 of other agencies that construct economic index numbers for policy.
 - 20
 - 21 • There should be a single set of criteria for determining which studies are of sufficient quality to be
22 included in current and future estimates of VRR.
 - 23
 - 24 • A 5-year interval for updating VRR estimates is appropriate.
 - 25
 - 26 • EPA should not restrict studies used for updating VRR to those published in peer-reviewed journals.
27 Studies outside of the peer-reviewed journals should be considered for inclusion following a
28 transparent and rigorous peer review process.
 - 29
 - 30 • The EPA should consider whether useful information can be extracted from other studies that could
31 improve estimates of VRR and its characteristics (e.g., latency, morbidity). This might include
32 studies of risk-risk tradeoffs, hedonic analyses in addition to hedonic wage studies, and risk studies
33 in the transportation safety literature.
 - 34
 - 35 • The EPA should not exclude studies based on non-national samples from use in updating VRR as
36 long as there is a set of studies that as a group is representative of the nation as a whole.
 - 37
 - 38 • EPA should consider a long term strategy of requiring that a more inclusive set of research results,
39 and even whole data sets, be made generally available for use by the research community and by
40 government agencies.

41

42 **3.4.2. Valuing Reductions in Risks of Cancer**

43

44 *Charge Question 12. In its 2011 report the SAB-EEAC recommended “...EPA work toward*
45 *developing a set of estimates...for policy-relevant cases characterized by risk...” (U.S. EPA*
46 *Science Advisory Board 2011, pp. 10). Among the studies that meet the selection criteria in the*

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1 *current White Paper, three stated preference studies provide values for reductions in risks of*
2 *cancer (i.e., Hammitt and Haninger 2010, Chestnut, Rowe, and Breffle 2012, and Viscusi, Huber*
3 *and Bell 2014). Only two of those studies (Hammitt and Haninger 2010 and Chestnut, Rowe,*
4 *and Breffle 2012) allow for a within study comparison of values for cancer and non-cancer risk*
5 *reductions. However, EPA could augment the literature by modifying the selection criteria to*
6 *include studies from other countries or from the grey literature, and/or using other methods*
7 *(e.g., risk-risk studies). Please comment on whether, and if so how, selection criteria for*
8 *identifying studies for estimating a cancer differential should differ from those used in the*
9 *current White Paper. Does the literature support a non-zero cancer differential?*

10
11 The SAB has previously concluded that “research suggests that people are willing to pay more for
12 mortality risk reductions that involve cancer than for risk reductions from accidental injury and proposes
13 a placeholder value that could be used for this cancer differential while the Agency pursues long-term
14 research to differentially value other types of risks” (U.S. EPA SAB 2011). The motivation behind a
15 potential cancer differential is that a death from cancer is preceded by a significant period of morbidity,
16 while a death from accidental injury may not be⁵. According to this motivation, a cancer death can be
17 thought of as two events, a period of morbidity followed by an early death. Logically, a death preceded
18 by a significant period of morbidity would be viewed as worse than a sudden accidental death (though
19 there may be some benefit to being given a period of time to put one’s affairs in order). Indeed, Gentry
20 and Viscusi (2015), using revealed preference wage data, find that wage premiums for occupational
21 mortality risks that tend to be preceded by longer periods of morbidity are higher than premiums for
22 occupational mortality risks that tend to be preceded by shorter periods of morbidity, and that the value
23 of a statistical life can be decomposed into a value of the fatality risk plus the value of the associated
24 morbidity risk. These studies show that people value both mortality risks and associated morbidity risks,
25 suggesting that a cancer premium could exist.

26
27 Given that a cancer premium is possible, is there enough evidence in the literature to establish its size?
28 Few studies have done clean comparisons of an estimated VSL for cancer-related deaths to a VSL for
29 sudden death. Hammitt and Haninger (2010) found that willingness to pay to reduce risk of death from
30 disease caused by consumption of pesticides was larger, but not statistically different from willingness
31 to pay to reduce risk of death from an automobile accident. Chestnut, Rose, and Breffle (2012) found
32 that willingness to pay to reduce risk of death from cancer was larger, but was not statistically different
33 from willingness to pay to reduce risk of death from heart attack. Cameron and Deshazo (2009)
34 compared VSL for sudden death to VSL for an illness profile that involved one or five years of illness
35 followed by death. They found that willingness to pay for a risk reduction was not significantly different
36 across these three treatments, though this comparison confounds morbidity and latency.

37
38 One study that did claim to find a cancer differential was Viscusi, Huber and Bell (2014). They estimate
39 a VSL for a cancer death of 10.85 million dollars. They compare this VSL to the median value of the
40 VSL for an accidental death estimated from several studies, which they find to be 9 million dollars.
41 From this they conclude that there is a positive cancer differential of twenty-one percent. Several points
42 should be made about their findings. First, the 10.85 million dollar VSL estimate is based on a VSL of
43 8.1 million dollars for a cancer death with a ten year latency. The 10.85 million dollar value was arrived
44 at by discounting over ten years at a discount rate of three percent. People may use some other method

⁵ It should be noted that a second motivation for a positive cancer differential has been proposed, namely that people associate a higher level of dread with cancer risks than with other health risks (Sunstein 1997, for example).

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1 than financial discounting to tradeoff between current health risks and future health risks. Second, while
2 Viscusi, Huber and Bell (2014) present confidence intervals for their VSL estimates, their own
3 robustness checks show that the estimated VSL for cancer risks is sensitive to their analytical approach.
4 Viscusi, Huber and Bell (2014) elicited willingness to pay values using a multiple-bounded dichotomous
5 choice method. They found, as is often the case, that the estimated VSL differs depending on whether
6 only the first response is used in the analysis or all responses are used. Specifically, they found that
7 using all three responses per respondent resulted in a VSL estimate that was thirty-one percent higher
8 than the VSL estimate based on only the first response. Had they used only the first response in their
9 analysis, they would have concluded that the value of a cancer VSL was actually less than the median
10 VSL value for accidental deaths. Based on available studies, the SAB concludes that there is not
11 sufficient evidence at this time to justify a non-zero cancer differential.

12
13 The SAB recommends that, instead of adopting a nonzero cancer differential, the EPA consider using
14 existing methods to value the morbidity that occurs prior to an early death, and add that estimated
15 morbidity value to conventional estimates of the value of the associated mortality. The EPA currently
16 values morbidity from cancer in cases where the cancer is not fatal, but does not value morbidity in fatal
17 cancer cases. The EPA should value cancer morbidity regardless of whether that morbidity leads to an
18 early death. This recommendation also applies to other environment-related mortality risks, including
19 cardio-pulmonary disease. Morbidity that occurs prior to an early death should be valued in all cases.
20 Mortality can then be valued using conventional VSL estimates.

21
22 The EPA should encourage and support ongoing research on whether willingness to pay to reduce the
23 risk of an early death preceded by a period of morbidity is correctly valued by summing the value of the
24 morbidity plus the value of the mortality. At this time, the SAB does not have evidence to suggest that
25 that approach would over- or under-state the true willingness to pay. Gray literature studies, studies
26 conducted outside the United States, and studies that do not directly estimate VSL, such as risk-risk
27 tradeoff studies and risk-benefit studies, could be assessed to determine whether there is evidence that
28 the VSL for different mortality risks differs, after having controlled for the value of associated
29 morbidity. <<*Chair's note: can we provide citations to relevant studies?*>> Such studies can help the
30 EPA and the SAB determine whether the SAB's recommendation should be reassessed. However, if and
31 when it is determined that a cancer differential (or a differential for other diseases) is justified, the same
32 selection criteria should be used to identify studies to measure the differential(s) as is used to identify
33 studies to establish the baseline VSL.

34
35 *Key Recommendations*

- 36
- 37 • Based on available studies, the SAB concludes that there is not sufficient evidence at this time to
38 justify a non-zero cancer differential. The SAB recommends that, instead of adopting a nonzero
39 cancer differential, the EPA consider using existing methods to value the morbidity that occurs prior
40 to an early death, and add that estimated morbidity value to conventional estimates of the value of
41 the associated mortality.
 - 42
43 • The EPA currently values morbidity from cancer in cases where the cancer is not fatal, but does not
44 value morbidity in fatal cancer cases. The EPA should value cancer morbidity regardless of whether
45 that morbidity leads to an early death. This recommendation also applies to other environment-
46 related mortality risks, including cardio-pulmonary disease.

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- 1
2 • The EPA should encourage and support ongoing research on whether willingness to pay to reduce
3 the risk of an early death preceded by a period of morbidity is correctly valued by summing the
4 value of the morbidity plus the value of the mortality. At this time, the SAB does not have evidence
5 to suggest that approach would over- or under-state the true willingness to pay.
6

7 **3.5. Income Elasticity of the Value of Statistical Life**

8
9 **3.5.1. Income Elasticity Literature**

10
11 *Charge Question 13. The EPA document Technical Memorandum: Income Elasticity presents a*
12 *summary of the recent income elasticity literature based on a review presented in Robinson and*
13 *Hammitt (2015). Please comment on whether Robinson and Hammitt (2015) and the EPA*
14 *Technical Memorandum provide an appropriate and scientifically sound summary of the income*
15 *elasticity of VSL (IEVSL) and income elasticity of non-fatal health effects literatures. If there are*
16 *additional relevant empirical studies that should also be included in the summary, please*
17 *provide citations.*
18

19 The SAB finds that Robinson and Hammitt (2015) and the EPA document *Technical Memorandum:*
20 *Income Elasticity* provide reasonable summaries of the income elasticity literature. The SAB does,
21 however, recommend that the EPA consider including the study by Murphy and Topel (2006) and the
22 meta-analysis by Mrozek and Taylor (2002) in the summary. Even if these studies are not included in
23 the EPA analysis, the agency should provide justification for not including the studies because they
24 provide information that should be relevant. The SAB generally finds is that very little (not enough)
25 research has been conducted in this important area. The EPA should support more research to provide
26 methodological guidance and empirical estimates of the income elasticity of VSL. One area to explore
27 further, in the absence of explicit studies, is the possibility of using estimates of the income elasticity for
28 other related goods and services to infer estimates of the income elasticity of VSL. <<**Chair’s note: it**
29 **would be helpful to provide some examples and citations to clarify what types of goods and services**>>
30 While this may not be straightforward, the ability to use such estimates would greatly increase the
31 empirical basis upon which to ground the income elasticity of VSL.
32

33 *Key Recommendations*

- 34
35 • Robinson and Hammitt (2015) and the EPA document *Technical Memorandum: Income Elasticity*
36 *provide reasonable summaries of the income elasticity literature. However, the EPA should consider*
37 *including the study by Murphy and Topel (2006) and the meta-analysis by Mrozek and Taylor*
38 *(2002) in the summary.*
39
40 • Very little research has been conducted on the income elasticity of the value of statistical life. The
41 EPA should support more research to provide methodological guidance and empirical estimates in
42 this important area.
43
44 • In the absence of explicit studies, the EPA should consider the possibility of using estimates of the
45 income elasticity for other related goods and services to infer estimates of the income elasticity of
46 the value of statistical life.

1
2 **3.5.2. Analysis of Very Low Income Elasticity Estimates**
3

4 *Charge Question 14. Several reported mean income elasticity estimates from stated preference*
5 *studies are quite low, sometimes even zero. The “balanced” approach in the EPA Technical*
6 *Memorandum does not include reported mean estimates of zero, but does include very low*
7 *reported mean estimates (e.g., 0.1). Please comment on whether this an appropriate and*
8 *scientifically sound choice. How should very low, non-zero, mean reported income elasticity*
9 *results be addressed in the analysis?*

10
11 The SAB finds that it is highly unlikely for the income elasticity of VSL to be zero or negative.
12 However, it is not completely clear how such estimates should be addressed in the EPA’s analysis. It can
13 be argued that such estimates may be theoretically impossible and therefore should be dropped, but it is
14 hard to find statistical justification for dropping them. One statistical justification for dropping them,
15 however, is that the income in these studies was not well measured, which may bias the estimates
16 toward zero. Imprecision in the quality of measurement will be partly reflected in the standard errors of
17 the individual income elasticity of statistical life estimates. Perhaps some of these estimates will not pass
18 the stricter validity tests that will be imposed as discussed in the response to Charge Question 1a. This
19 may render these points moot.

20
21 The SAB recommends that the EPA adopt the following strategies:

- 22
23 1. Instead of calculating an unweighted mean of income elasticity of VSL estimates, use standard
24 errors of individual income elasticity of VSL estimates to calculate a weighted mean.
25
26 2. Given the lack of congruence on the low/zero estimates, calculate the weighted mean of the
27 income elasticity of VSL both with and without the low/zero estimates to assess their influence.
28

29 *Key Recommendations*
30

- 31 • Instead of calculating an unweighted mean of income elasticity of VSL estimates, the EPA should
32 use standard errors of individual income elasticity of VSL estimates to calculate a weighted mean.
33
34 • Given the lack of congruence on the low/zero income elasticity of VSL estimates, the EPA should
35 calculate the weighted mean of the income elasticity of VSL both with and without the low/zero
36 estimates to assess their influence
37

38 **3.5.3. Study Selection Criteria and Alternative Approaches for Estimating Central Income**
39 **Elasticity of Value of Statistical Life**
40

41 *Charge Question 15. Please comment on whether the selection criteria applied by Robinson and*
42 *Hammit (2015) are clearly enumerated, appropriate, and scientifically sound and whether the*
43 *additional inclusion of Viscusi, Huber, and Bell (2014) in the Technical Memorandum is*
44 *appropriate based on results reported in the study’s on-line appendix (attached).*
45

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1 *Charge Question 16. Given the relatively limited number of studies upon which to draw for*
2 *estimating the income elasticity of VSL, the EPA Technical Memorandum describes two*
3 *alternatives for arriving at a central income elasticity of VSL estimate and range for use in*
4 *environmental policy analysis. Of these alternatives which is the most appropriate and*
5 *scientifically sound? Please provide the rationale for your choice. Would it be appropriate to*
6 *consider using the alternative as a sensitivity or uncertainty characterization?*

7
8 Charge questions 15 and 16 pertain to the same general topic, how to best arrive at an estimate of the
9 income elasticity of the VSL. These charge questions are therefore discussed together.

10
11 *EPA’s Selection Criteria and Alternatives for Estimating Income Elasticity of VSL*

12
13 The SAB finds that neither of the two alternatives put forward in Robinson and Hammitt (2015) and
14 described in EPA’s technical memorandum represent an adequate basis for providing an estimate(s) of
15 the income elasticity of VSL for policy purposes. With regard to the first option, using the central
16 estimates and range from a meta-analysis, Robinson and Hammitt (2015) do an admirable job
17 summarizing the available literature. Their analysis, however, drives home the point that there is not an
18 adequate informational basis for deriving a consensus estimate of the income elasticity of VSL. The
19 inclusion or non-inclusion of the Viscusi, Huber and Bell (2014) does not alter this conclusion.
20 Robinson and Hammitt’s (2015) inclusion of studies that are publically available, but not in the peer
21 reviewed literature clashes with the EPA study selection criteria used for determining a central estimate
22 for the VSL, but is best seen as an indication of the lack of an adequate information basis for estimating
23 a central value for the income elasticity of VSL. The second option that Robinson and Hammitt (2015)
24 put forward is to use estimates from the Viscusi (2015) meta-analysis of hedonic pricing results that rely
25 on the CFOI data. This meta-analysis is recent and was performed competently but the set of studies
26 used is somewhat narrow. The preferred estimates from this study are substantially larger than those
27 found in other recent meta-analyses that draw on broader set of studies, including those by Lindhjem, et
28 al. (2011) and Doucouliagos, Stanley and Viscusi (2014) which suggest much lower central values for
29 the income elasticity of VSL.

30
31 *Nature of the Problem Faced in Estimating Income Elasticity of VSL*

32
33 It is useful to understand several aspects of the nature of the problem faced in arriving at an estimate of
34 the income elasticity of VSL for policy purposes.

- 35
36 1. To estimate the income elasticity of VSL, variation in income is needed. However, there has
37 been relatively little change in median income over the last two decades. Changes in per capita
38 income have been more pronounced, but much of the change has been in the two tails of the
39 income distribution. This calls into question what the appropriate income variable is if a causal
40 relationship is needed.
41
42 2. Some studies estimate the income elasticity of VSL from a cross section of individuals while
43 others estimate the income elasticity of VSL from time series data. It is well known that
44 estimates based on cross sectional data measure what would be expected to happen to an
45 individual’s VSL if that individual swapped income with someone else in the current income
46 distribution. In contrast, income elasticity of VSL estimates based on a time series measure

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1 provide an estimate of how VSL statistics would shift if the entire income distribution rises or
2 falls. The EPA’s use of income elasticity of VSL estimates to adjust VSL estimates over time
3 generally calls for a time series-based measure.
4

- 5 3. The hedonic wage approach does not, by design, provide an estimate of the income elasticity of
6 VSL.⁶
7
- 8 4. While stated preference studies are carefully designed to produce reliable VSL estimates, this is
9 not the case for income elasticity of VSL estimates. The single income question asked in the
10 typical stated preference survey is most often taken from standard government surveys and its
11 initial use is to help make a determination as to whether the data collected are adequately
12 representative of the population of interest with respect to income. This is done by comparing the
13 distribution in income to that of U.S. Census Bureau statistics. This type of income question is
14 known to be fraught with measurement error due to substantial respondent heterogeneity with
15 respect to what constitutes income and to suffer from having a high rate of missing values.⁷ It
16 has long been known that in order to adequately measure income, a very large set of questions
17 about specific types of income and monetary transfers is required.⁸ Furthermore, from a
18 theoretical perspective, income is not the correct variable that should help determine the risk-
19 wage tradeoff but rather the correct variable is medium term discretionary wealth. The best that
20 can be hoped for is that a simple regression of this variable on income, as typically measured in
21 surveys, has independent and identically distributed normal error terms. In this case, the presence
22 of classical measurement error is known to bias the estimate of the income elasticity of VSL
23 downward, a result that has considerable support in the broader literature on income elasticities.
24

25 *Methodologies for Estimating Income Elasticity of VSL*

26
27 Smith and Evans (2010) identify four methodologies to estimate the income elasticity of VSL: (1) stated
28 preference studies; (2) meta-analyses of hedonic wage studies; (3) cross-country comparisons of VSL
29 estimates; and (4) comparisons of VSL estimates at different points in time for a single country.

30 Robinson and Hammitt (2015) concentrate on the first two. The two main problems with the stated
31 preference estimates of the income elasticity of VSL were noted previously: they are cross-sectional
32 estimates rather than time series estimates and they suffer from substantial measurement error problems
33 with respect to income. A meta-analysis of hedonic wage studies might serve as a basis on which to
34 estimate the income elasticity of VSL. However, to make this work one needs a large number of studies
35 across time periods with both income variation and a relatively constant mix of estimation techniques
36 used to estimate the VSL in those different time periods. Unfortunately, there are not a large number of
37 available studies and the desire of journals to publish papers using new methodologies means that

⁶ The use of quantile regression, e.g., Kniesner et al. (2010) and Evans and Schaur (2010), to estimate a hedonic wage equation can potentially provide a cross-sectional estimate of the income elasticity of VSL at different points in the wage distribution if there is wage-related heterogeneity in the wage-risk tradeoffs being made by individuals in the sample.

⁷ A common example here is that some retired people view drawing money from a retirement savings account like an IRA to be income while others don't.

⁸ For the two exemplars of purpose built that do this, see the Survey of Consumer Finances sponsored by the U.S. Federal Reserve Board and the U.S. Census Bureau's Survey of Income and Program Participation.

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1 particular methodologies for estimating the VSL are always confounded with time/income variation.⁹
2 Using cross-country comparisons of VSL estimates is an attempt to increase the range of income levels
3 observed and hence to be able to statistically estimate the income elasticity of VSL with reasonable
4 precision. There are several difficulties with this approach. The preferences of people in other countries
5 may be different from people living in the United States. Indeed, this is the rationale advanced by the
6 EPA for not relying on VSL estimates in other countries. A variant of the cross sectional data problem is
7 seen when considering the situation where the different VSL estimates used in estimating the income
8 elasticity of VSL come from different countries in the same year.

9
10 The fourth approach of comparing VSL estimates at different points in time from a single country
11 provides a coherent way to obtain an income elasticity of VSL estimate for policy purposes. An example
12 of this approach is found in Costa and Kahn (2004) who look at the evolution of the VSL from 1940 to
13 1980. Their work is not relevant to the EPA's current need because their analysis stops in 1980 and the
14 Cost of Funds Index (COFI) risk data being used in current hedonic wage studies does not exist for the
15 time period Costa and Kahn examine. It would be possible, however, to take one of the currently
16 preferred VSL model specifications that can be estimated by combining the U.S. Census Bureau's
17 Annual Social and Economic Supplement to the Current Population Survey (CPS) with COFI data.¹⁰ By
18 holding the methodology and data sources used to estimate the VSL constant, it should be possible to
19 use the income variation over the last two decades to obtain a defensible income elasticity of VSL
20 estimate.¹¹ Each annual cross section of the CPS, can be used to produce a VSL estimate. To each of
21 these VSL estimates, the desired measure of income for that year can be attached. Calculation of the
22 income elasticity of VSL is then a straightforward econometric exercise. The sensitivity of the income
23 elasticity of VSL estimate to the different model specifications for estimating the VSL can be examined
24 and the resulting income elasticity of VSL estimates averaged if there is not a clear reason for favoring
25 one model specification over another. The sensitivity of the income elasticity of VSL estimate to the
26 particular definition of income can also be examined. For example, income elasticity of VSL estimates
27 could be estimated using median per capita income and gross domestic product (GDP) per capita. The
28 income elasticity of VSL estimate(s) to be used in assessing regulations could be updated at regular
29 intervals simply by adding VSL estimates based on more recent years of the CPS, with earlier time
30 period perhaps given less weight in determining the income elasticity of VSL estimate.

31
32 **Key Recommendations**

- 33
34 • Neither of the two alternatives put forward in Robinson and Hammitt (2015) and described in EPA's
35 technical memorandum represent an adequate basis for providing an estimate(s) of the income
36 elasticity of VSL for policy purposes. Therefore the SAB recommends that the EPA consider an
37 alternative approach.

⁹ It would also be desirable to have a number of distinct data sources among the studies used the meta-analysis that were evenly distributed over time periods with different income. Unfortunately, the available studies often share some common data sources but are idiosyncratic enough with respect how key variables are constructed that these differences too are confounded with the specific time period when the study was conducted.

¹⁰ Some of hedonic wage regressions use the COFI rates averaged over multiple years. Doing this is similar to including a lagged regressor the sense of reducing the effective number of observations in the regression model by the length of the lag period.

¹¹ Much of the effort would be in the form of preparing the CPS and COFI data for the first cross-sectional hedonic wage regression. Because subsequent cross-sections would use the same variable definitions and industry-occupation fatality rates, the data preparation and program effort involved should be substantially reduced.

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- Comparing VSL estimates at different points in time from a single country provides a coherent way to obtain an income elasticity of VSL estimate for policy purposes. The SAB recommends selecting one of the currently preferred VSL model specifications that can be estimated by combining the U.S. Census Bureau’s Annual Social and Economic Supplement to the Current Population Survey (CPS) with COFI data and using the income variation over the last two decades to obtain a defensible income elasticity of VSL estimate.
- The SAB recommends examining the sensitivity of the income elasticity of VSL estimate to different model specifications and averaging the resulting income elasticity of VSL estimates if there is not a clear reason for favoring one model specification over another.

3.5.4. Income Elasticity of the Value of Non-fatal Health Effects

Charge Question 17. As described in Robinson and Hammitt (2015), there are limited data on income elasticity of non-fatal health effects. As a result the Technical Memorandum recommends using the income elasticity of VSL to estimate income elasticity for the value of these non-fatal health risks. Please comment on whether this represents an appropriate and scientifically sound approach given the available data.

The SAB recognizes that there are limited data available on income elasticity of non-fatal health effects but does not fully support using the income elasticity of VSL to estimate income elasticity for the value of these non-fatal health risks as an interim solution. The SAB finds that it is conceptually incorrect to apply income elasticity for one good to some other good, even though the two goods are related in some way. Moreover, both the magnitude of the valuation estimates and the income elasticities seem likely to be influenced by changes in national health insurance policies.

The SAB recommends that the EPA explore the income elasticity of expenditures on private health care products as a better proxy for the income elasticity of non-fatal health risks. <<**Chair’s note: can we provide citations?**>>

Key Recommendations

- The SAB does not fully support using the income elasticity of VSL to estimate income elasticity for the value of fatal health risks because it is conceptually incorrect to apply income elasticity for one good to some other good. The SAB recommends that the EPA explore the income elasticity of expenditures on private health care products as a better proxy for the income elasticity of non-fatal health risks.

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APPENDIX A: THE EPA'S CHARGE QUESTIONS

Charge Questions for SAB-EEAC Review of an EPA White Paper: “Valuing Mortality Risk for Environmental Policy: a Meta-analytic Approach” and Technical Memorandum: “Income Elasticity of VSL”

February 2016

White Paper: Meta-analysis dataset

The White Paper assembles a database of stated preference and hedonic wage estimates of the value of statistical life (VSL) and, where possible, their standard errors. Criteria for inclusion in the database are based on recommendations from the SAB-EEAC (U.S. EPA Science Advisory Board 2011) (see section 4.4, page 13-20). EPA requests comments on whether the selection criteria previously recommended by the SAB-EEAC were appropriately interpreted and applied both for selecting studies to include in the meta-analysis and for selecting estimates within studies. **In answering questions 1(a) – 1(c), in addition to responding to the specific questions, please comment, in general, on whether the selection criteria previously recommended by the SAB-EEAC have been appropriately interpreted and applied in the White Paper.**

1a. Evidence of validity for stated preference studies: The SAB noted in its earlier advisory report (U.S. EPA Science Advisory Board 2011) that each selected stated preference study “should provide evidence that it yields valid estimates” (page 16). The SAB did not, however, specify how validity should be assessed. In applying this criteria, EPA included studies and estimates that passed a weak scope test or provided other evidence of validity (e.g., a positive coefficient on the risk variable as in the appendix for Viscusi, Huber and Bell 2014) as explained in Appendix B of the White Paper. Please comment on whether the methods EPA used in the White Paper to assess the validity of studies and estimates are appropriate and scientifically sound.

1b. Construct of the risk variable in hedonic wage studies: The SAB noted in its earlier advisory that the EPA should “Eliminate any study that relies on risk measures constructed at the industry level only (not by occupation within an industry)” (U.S. EPA Science Advisory Board 2011, page 18). It is not clear whether the SAB’s parenthetical addition was meant as an example or as a directive. Only four studies constructed the risk variable by occupation and industry and met other selection criteria. In applying this criteria EPA included studies and estimates where the risk measure is differentiated by industry and at least one other characteristic (e.g., occupation, gender, age). Please comment on whether the hedonic wage studies included in the White Paper constructed the risk variable in a manner appropriate for use in the meta-analysis.

1c. Estimates for immediate risk reductions: To estimate the average value of the marginal willingness to pay for reduced risk of immediate death, the EPA selected estimates from the Stated Preference literature that are most closely comparable to the accidental deaths from the hedonic wage literature. The EPA made several judgement calls in determining the appropriate estimates to use from the stated preference literature. Specifically, Viscusi, Huber and Bell (2014) estimate reductions in risk of bladder cancer that will occur in 10 years. The authors discount the estimates to derive a comparable estimate for an immediate risk reduction. Alberini, et al. (2004) estimate a willingness to pay for an annual

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1 reduction in risk over 10 years. We include estimates from both of these studies in the meta-analysis.
2 Please comment on whether appropriate estimates from the stated preference literature were used in the
3 White Paper to estimate the marginal willingness to pay for reduced risk of immediate death.

- 4
- 5 2. Please comment on whether relevant empirical studies in the stated preference and hedonic wage
6 literatures are adequately captured in the White Paper. If additional studies should be included in
7 the white Paper please provide citations.
8
- 9 3. Some estimates in the meta-analysis dataset in the White Paper are constructed by weighting
10 subpopulation-specific estimates within a study in order to approximate an estimate for the
11 general population. The specific weights used are described in Appendix B of the White Paper.
12 Please comment on whether the population-weighting approach used in the White Paper is
13 appropriate and scientifically sound.
14
- 15 4. In some cases EPA estimated standard errors in the White Paper using information within studies
16 or provided by the study authors, as described in Appendix B. Please comment on whether the
17 methods used in the White Paper to estimate standard errors when such information was not
18 readily available are appropriate and scientifically sound.
19
20

21 **White Paper: Analysis**

22

23 Section 4 of the White Paper describes methods used to estimate representative VSL estimates from the
24 meta-analysis dataset and presents results.

- 25
- 26 5. Please comment on whether the methodology used in the White Paper to analyze the data
27 represents an appropriate and scientifically sound application of meta-analytic methods to derive
28 generally applicable VSL estimates for environmental policy analysis.
29
- 30 6. The White Paper classifies estimates into independent samples, also called groups, as described
31 in Section 4. Estimates from some hedonic wage studies that use the same or very similar
32 worker samples are grouped together for the analysis. Similarly, some of the stated preference
33 estimates using the same sample are grouped together. Please comment on whether this
34 methodology represents an appropriate and scientifically sound approach for accounting for
35 potential correlation of results that rely on the same underlying data.
36
- 37 7. Section 4.1 of the White Paper presents an expression that characterizes optimal weights that
38 account for sampling and non-sampling errors, a framework that guides EPA's approach. Please
39 comment on whether this is an appropriate and scientifically sound approach for addressing
40 sampling and non-sampling errors.
41
- 42 8. The analysis in the White Paper adopts both non-parametric and parametric approaches (sections
43 4.1 and 4.2, respectively). Please comment on whether these approaches span a reasonable range
44 of appropriate, scientifically sound, and defensible approaches to estimating a broadly applicable
45 VSL for environmental policy and whether there are other methods that are more appropriate
46 than those used in the White Paper.

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White Paper: Results

- 9. The White Paper presents estimates using parametric and non-parametric models, pooled across stated preference and hedonic wage studies as well as balanced (i.e., equal weight to each study type), and weighted using different approaches. Of the range of estimates presented (see Section 4) the White Paper proposes the use of estimates from the following models:
 - Non-parametric model, balanced, mean of study mean
 - Parametric, balanced

Please comment on whether these proposed estimates represent reasonable and scientifically sound conclusions from the analyses in the White Paper and whether there is a different set (or sets) of results that are preferable based on the data and analysis in the White Paper.

- 10. The results section of the White Paper concludes with an influence analysis. Please comment on whether this analysis is a reasonable way to characterize the influence of individual studies on the estimated VSLs, whether the results of the influence analysis suggest any changes or modifications to the estimation approach, and whether it is important to include an influence analysis.

Establishing a Protocol for Future Revisions:

- 11. In the previous SAB advisory report (USEPA Science Advisory Board 2011), the SAB endorsed the idea of establishing a standardized protocol and regular schedule for future updates to the Agency’s mortality risk valuation estimates. Please comment on relevant statistical criteria for the inclusion of additional eligible estimates and/or the exclusion of older estimates that could help inform the development of a standardized protocol for future updates and the timing or frequency of those updates.
- 12. In its 2011 report the SAB-EEAC recommended “...EPA work toward developing a set of estimates...for policy-relevant cases characterized by risk...” (U.S. EPA Science Advisory Board 2011, pp. 10). Among the studies that meet the selection criteria in the current White Paper, three stated preference studies provide values for reductions in risks of cancer (i.e., Hammitt and Haninger 2010, Chestnut, Rowe, and Breffle 2012, and Viscusi, Huber and Bell 2014). Only two of those studies (Hammitt and Haninger 2010 and Chestnut, Rowe, and Breffle 2012) allow for a within study comparison of values for cancer and non-cancer risk reductions. However, EPA could augment the literature by modifying the selection criteria to include studies from other countries or from the grey literature, and/or using other methods (e.g., risk-risk studies). Please comment on whether, and if so how, selection criteria for identifying studies for estimating a cancer differential should differ from those used in the current White Paper. Does the literature support a non-zero cancer differential?

1 **Technical Memorandum: Income elasticity**
2

- 3 13. The EPA document *Technical Memorandum: Income Elasticity* presents a summary of the recent
4 income elasticity literature based on a review presented in Robinson and Hammitt (2015).
5 Please comment on whether Robinson and Hammitt (2015) and the EPA Technical
6 Memorandum provide an appropriate and scientifically sound summary of the income elasticity
7 of VSL (IEVSL) and income elasticity of non-fatal health effects literatures. If there are
8 additional relevant empirical studies that should also be included in the summary, please provide
9 citations.
10
- 11 14. Several reported mean income elasticity estimates from stated preference studies are quite low,
12 sometimes even zero. The “balanced” approach in the EPA Technical Memorandum does not
13 include reported mean estimates of zero, but does include very low reported mean estimates
14 (e.g., 0.1). Please comment on whether this an appropriate and scientifically sound choice. How
15 should very low, non-zero, mean reported income elasticity results be addressed in the analysis?
16
- 17 15. Please comment on whether the selection criteria applied by Robinson and Hammitt (2015) are
18 clearly enumerated, appropriate, and scientifically sound and whether the additional inclusion of
19 Viscusi, Huber, and Bell (2014) in the Technical Memorandum is appropriate based on results
20 reported in the study’s on-line appendix (attached).
21
- 22 16. Given the relatively limited number of studies upon which to draw for estimating the income
23 elasticity of VSL, the EPA Technical Memorandum describes two alternatives for arriving at a
24 central IEVSL estimate and range for use in environmental policy analysis. Of these alternatives
25 which is the most appropriate and scientifically sound? Please provide the rationale for your
26 choice. Would it be appropriate to consider using the alternative as a sensitivity or uncertainty
27 characterization?
28
- 29 17. As described in Robinson and Hammitt (2015), there are limited data on income elasticity of
30 non-fatal health effects. As a result the Technical Memorandum recommends using the IEVSL
31 to estimate income elasticity for the value of these non-fatal health risks. Please comment on
32 whether this represents an appropriate and scientifically sound approach given the available data.
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1 **APPENDIX B BIBLIOGRAPHY ON WILLINGNESS TO PAY IN HEALTH**
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1 **APPENDIX C: BIBLIOGRAPHY ON BENEFIT-RISK AND RISK-RISK**
2 **TRADEOFF PREFERENCES IN HEALTH AND HEALTH CARE [PARTIAL]**

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