INDUSTRIAL ECONOMICS, INCORPORATED

2067 Massachusetts Avenue Cambridge, Massachusetts 02140 Telephone 617/354-0074 Facsimile 617/354-0463

MEMORANDUM

15 August 2005

TO: Nona Smoke, EPA/OPAR

FROM: Chip Paterson, Jim Neumann and Chris Leggett, IEc

CC: James DeMocker, EPA/OPAR, Bryan Hubbell, EPA/OAQPS, Don McCubbin, Abt Associates

SUBJECT: Recommended Residential Visibility Values for the Section 812 Second Prospective Analysis

The purpose of this memorandum is to propose valuation information for use in estimating benefits associated with improved residential visibility under Section 812 of the Clean Air Act Amendments. The recommendations described here follow from the Science Advisory Board Council's direction to revisit available literature for these purposes, as well as IEc's previous (September 30, 2004) memorandum addressing visibility valuation (attached as Appendix A).[1]

As previously discussed, we recommend transferring results from three contingent valuation studies of residential visibility, expressed in comparable terms according to a function similar to that relied upon in the First Prospective analysis and originally described by Chestnut and Rowe (1990a). In the following section we describe the steps involved in extracting values from each of these studies and then discuss the manner in which they are transferred to other geographic areas.

[1] Memo from Chris Leggett and James Neumann, IEc to Nona Smoke, EPA/OPAR dated September 30, 2004 and *Review of the Revised Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act 1990-2020*, Science Advisory Board Advisory Council on Clean Air Compliance Analysis, May 2004.

Summary of Selected Valuation Information

Five principal residential visibility valuation studies were identified and reviewed for quality and applicability: Brookshire et al. (1979), Loehman et al. (1984), McClelland et al. (1991), Rae (1983) and Tolley et al. (1986). Of these, we exclude McClelland (1991) due to various concerns articulated by a previous Council. In addition, we exclude Rae (1983) because it represents a novel application of a choice method for which there existed no established practices for design, implementation and data analysis. While the remaining three studies represent early applications of the contingent valuation method (and therefore do not benefit from more recent methodological advances or best-practice guidelines established by the NOAA Panel and other diagnostic research), they nonetheless build upon previous literature and incorporate varying degrees of tests for internal consistency. As the Council notes, these studies provide information regarding the likely magnitude of residential visibility benefits and warrant re-consideration for purposes of benefits analysis.

Exhibit 1 on the following page provides a summary of attributes of the remaining three studies. Of these, Loehman et al. (1984) and Brookshire et al. (1979) were subsequently published in peer-reviewed journals (see Loehman et al., 1994 and Brookshire et al., 1982). The Tolley et al. (1986) work was not published, but was subject to peer review during study development. Previous visibility literature summaries (e.g., Chestnut and Rowe, 1990a and Chestnut and Dennis, 1997) and IEc's September 30, 2004 memorandum provide detailed descriptions of the three studies. These sources, as well as a review of the Tolley et al. study (Chestnut and Rowe, 1986) and Leggett et al. (2004b) also discuss criticisms associated with each study.

In extracting study values, we follow procedures similar to those described by Chestnut and Rowe (1990a) in their original summary of this literature for the National Acid Precipitation Assessment Program.[2] The results of our replication efforts yielded nearly identical common values (when adjusted to comparable dollar-years) for the Loehman et al. (1984) and Tolley et al. (1986) studies. Our calculated average values for Brookshire et al. (1979) are roughly 25 percent lower than those reported by Chestnut and Rowe (1990a). The reason for this discrepancy is not clear.

[2] As described in Chestnut and Rowe (1990a) and personal communication, Lauraine Chestnut, 23 May 2005.

Exhibit 1 Summary of Selected Contingent Valuation Studies			
Study	**Location**	**Survey Mode and Year Conducted**	**Summary of Valuation Scenario**
Brookshire et al. (1979)	Los Angeles	In-person interviews, 1978	o Survey elicited values for improvements to average air quality using photographs depicting "poor," "fair," and "good" conditions, corresponding to visual ranges of two, 12 and 28 miles, respectively. o Values for visibility, visibility and acute health effects, and visibility, acute and chronic health effects were elicited in sequence and the sequence was varied across respondents.
Loehman et al. (1984)	San Francisco Bay area	In-person interviews, 1980	o Visibility changes were presented to respondents in the form of an annual distribution of clear, moderate and poor quality days. Respondents were also shown a distribution of health risks. o Respondents were asked what they would be willing to pay for improved combinations of visibility and health conditions, which represented either an improvement in health, visibility, or both.
Tolley et al. (1986)	Chicago, Atlanta, Boston, Mobile, Washington D.C., Cincinnati, Miami and Denver	In-person interviews, 1981, 1982 and 1984	o The first survey, conducted in Chicago, elicited values for improvements in visual range from nine to 18 or 30 miles. o Subsequent surveys conducted in Atlanta, Boston, Mobile, Washington D.C., Cincinnati and Miami considered improvements of 10 and 20 miles over the stated prevailing visual range and utilized photographs from Chicago. o Additional surveys conducted in Chicago, Atlanta and Denver in 1984 utilized photographs from the respondent's city. These also described improvements in visual range of 10 to 20 miles.

Each study provides estimates of household willingness to pay (WTP) to improve visibility conditions from a status quo visual range to an improved visual range. To express these value estimates in comparable terms, we rely upon a function similar to that used in the First Prospective analysis:

$$WTP = b * \ln\left[\frac{VR2}{VR1}\right]$$

where:

WTP = annual household willingness to pay
VR2 = mean annual visual range in miles after the improvement,
VR1 = mean annual visual range in miles before the improvement, and
b = parameter

As originally described by Chestnut and Rowe (1990a), this function implies a constant WTP for a given percentage change in visual range. This is consistent with the Agency's current use of the deciview scale, which relates to the above function in the following manner:

$$WTP = \frac{b}{10} * \left[DV1 - DV2\right]$$

where:

DV (deciviews) = 10*[ln(243/VR)]

This function naturally implies a constant WTP for a given change in deciviews.

For expository purposes, we describe valuation information from the three studies in terms of changes in visual range, though the relationship to the deciview scale should be clear from above. Again following Chestnut and Rowe (1990a), we utilize value estimates and the associated change in visual range from each study to estimate the *b* parameter for eight study areas. Where studies provide multiple estimates for visual range improvements, *b* is estimated via simple regression. Exhibit 2 below provides a summary of these estimates, as well as an illustrative implied WTP value for a 10-percent improvement in visual range. All estimates are expressed in $2004 according to the Consumer Price Index.

Exhibit 2 Summary of Visibility Valuation Information			
City[a]	**Study**	***b* Estimate[b]**	**Implied WTP for 10% Improvement in Visual Range[a]**
Atlanta	Tolley et al. (1986)	401	$38
Boston	Tolley et al. (1986)	491	$47
Chicago	Tolley et al. (1986)	388	$37
Denver	Tolley et al. (1986)	903	$86
Los Angeles	Brookshire et al. (1979)	118	$11
Mobile	Tolley et al. (1986)	386	$37
San Francisco	Loehman et al. (1984)	1,225	$117
Washington, DC	Tolley et al. (1986)	757	$72
[a]Recognizing potential fundamental issues associated with data collected in Cincinnati and Miami (e.g., see Chestnut and Rowe, 1986 and 1990a), we do not include values for these cities in our analysis. [b]*b*/10 = WTP for a one deciview improvement [c]Annual household willingness to pay, $2004			

As shown, the implied annual per-household WTP estimates for a hypothetical 10-percent improvement range from $11 to $117, with a mean of $56 and median of $43. It is not surprising that such a range of values exists, as these areas all feature different landscapes and vistas, populations and prevailing visibility conditions.

Transfer of Values to Out-of-Study Regions

To estimate visibility benefits in locations other than those considered in the three studies, we transfer the *b* parameters from the eight study areas based on geographic proximity. In particular, we consider two scenarios:

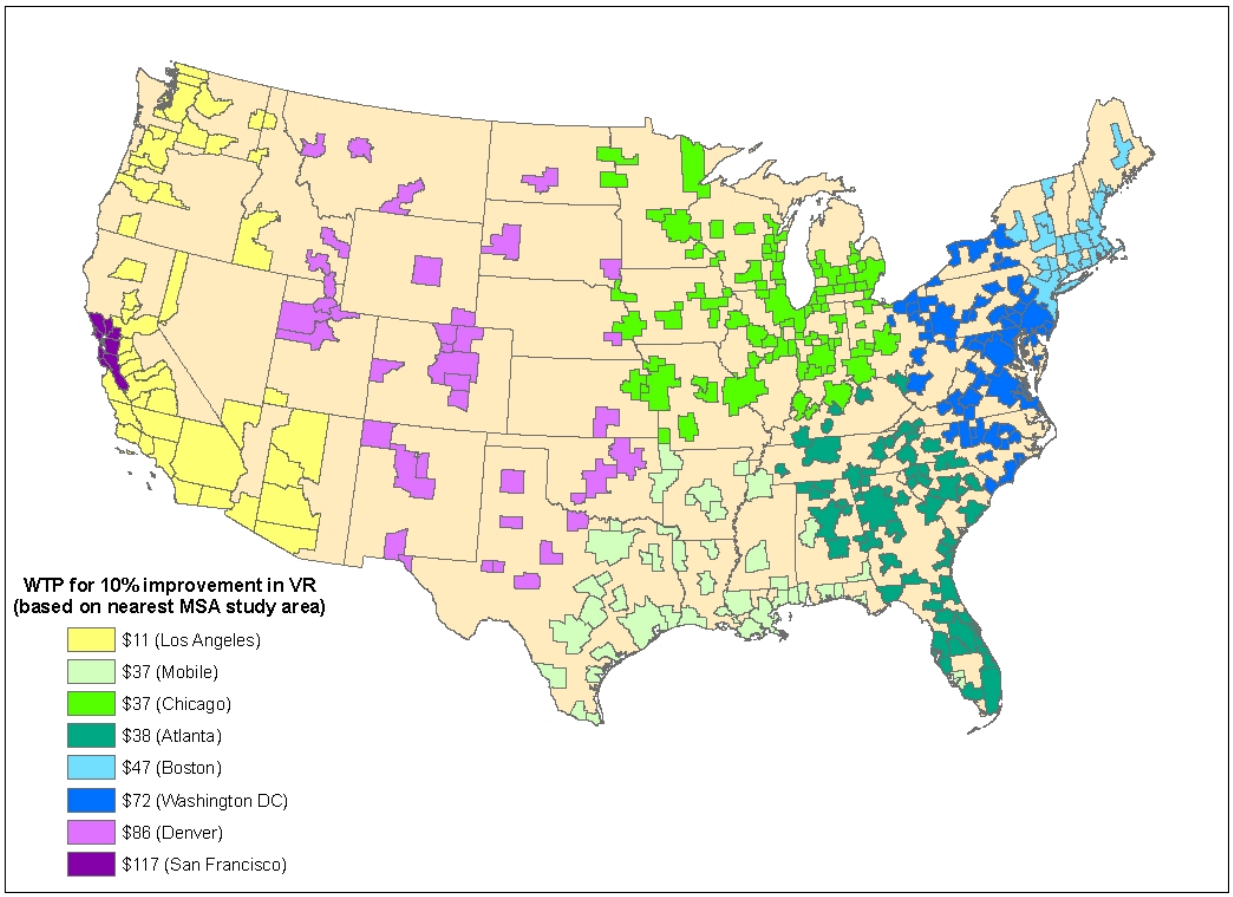
Scenario 1: Transfer to all MSAs

The studies we rely upon were all conducted in urban/metropolitan and surrounding areas and generally do not provide information on values for residential visibility improvements in rural areas. Thus, we restrict transfer of values to Metropolitan Statistical Areas (MSAs).[3] While MSAs account for roughly 20 percent of total U.S. land area, over 80 percent of the population resides within them (Census 2000). We assign each of the 359 MSAs in the contiguous U.S. a value based on geographic proximity to one of the eight study cities, with one exception. We apply the Loehman et al. (1984) value only to the six San Francisco Bay area MSAs. The Loehman et al. study is unique among the three in the manner in which visibility changes were described to respondents (i.e., a distribution of days versus average conditions). In

[3] MSA boundaries are as most recent defined (2003).

addition, the study area is unique in the landscape and vistas it offers, as well as prevailing weather conditions. In light of these factors, and considering that the Loehman et al. (1984) value is over 30 percent higher than the next highest value in the range, we feel it is conservative and appropriate to restrict this value to the study region. Figure 1 displays all MSAs and their assigned values (again, the hypothetical 10-percent improvement for illustrative purposes) based on the closest study MSA *b* parameter. A full list of MSAs and their associated values is provided in Appendix B.

Figure 1. MSAs with Assigned Residential Visibility Values

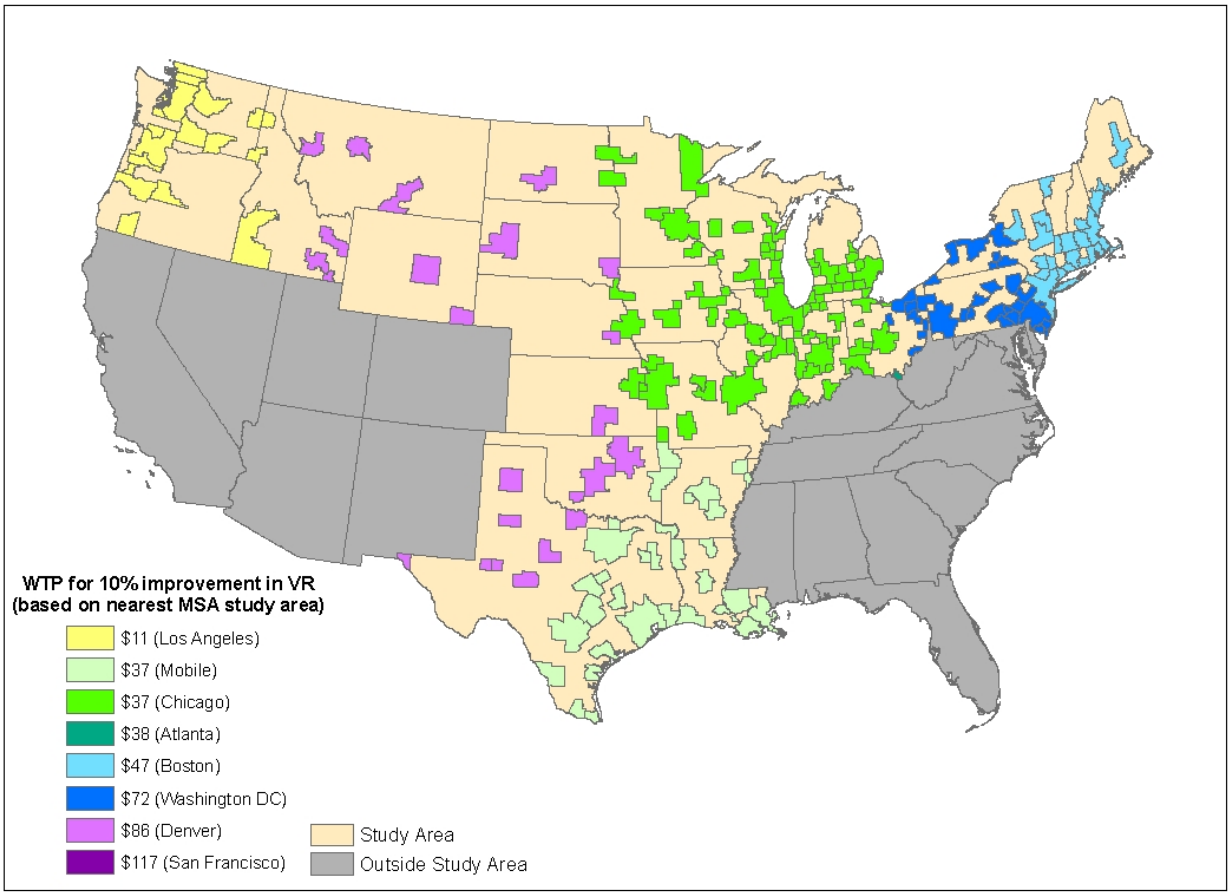


Scenario 2: Exclude Chestnut and Rowe (1990b) Recreational Regions

As described in the September 30, 2004 memo, it is conceivable that respondents to Chestnut and Rowe's (1990b) recreational visibility survey may have partially included values for their own residential visibility when evaluating changes at national parks and wilderness areas in their region. For this reason, we also propose an alternative scenario where MSAs in California, the Colorado Plateau and the Southeast (regions where values were elicited from residents for visibility improvements in their region) are excluded from the geographic

aggregation of residential visibility values. Figure 2 displays the excluded regions under this second scenario. The 159 excluded MSAs are also indicated in the Appendix table.

Figure 2. Regions Excluded from Residential Visibility Benefit Analysis under Alternative Scenario



Next Steps

We anticipate that Abt Associates will utilize the *b* (or per-deciview) information to calculate benefits associated with predicted visibility changes on a county-by-county basis.[4] In this manner, there are two issues that may warrant further attention.

In estimating the *b* parameters for each study, we include all values for *improvements* in visual range. Chestnut and Rowe (1990a) also include WTP values to avoid reductions in visual range (where available) in *b* estimation. A casual comparison of values from Loehman et al. and Tolley et al. suggests that WTP to avoid reductions in visual range is significantly higher than WTP for similar improvements, which is consistent with the notion that equivalent gains and

[4] Current MSA definitions follow county boundaries in all regions.

losses are viewed differently. This issue is discussed formally in Loehman's subsequent published work (Loehman et al., 1994). While we feel that restricting our present analysis to valued improvements is appropriate and conservative, we recognize that predicted policy scenarios might actually imply visibility degradation in some areas. One natural approach would involve transferring information from Loehman et al. and Tolley et al., who both consider WTP to avoid losses; however, this issue warrants additional consideration.

We also anticipate that Abt Associates will adjust transferred values for regional differences in income using an elasticity estimate. We understand that the Agency currently relies upon an estimate derived from the Chestnut and Rowe (1990b) recreational visibility study. As discussed in the September 30, 2004 memorandum, there may be reason to expect the income elasticity of WTP for residential visibility to differ from that for recreational visibility. Thus, whether a more appropriate estimate could be recovered from the residential visibility literature should also be considered.

References Cited

Brookshire, D.S., Thayer, M.A., Schulze, W.D. & D'Arge, R.C. 1982. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches." *The American Economic Review.* 72(1): 165-177.

Brookshire, D.S., R.C. d'Arge, W.D. Schulze and M.A. Thayer. 1979. *Methods Development for Assessing Tradeoffs in Environmental Management, Vol. II: Experiments in Valuing Non-Market Goods: A Case Study of Alternative Benefit Measures of Air Pollution Control in the South Coast Air Basin of Southern California*. Prepared for the U.S. Environmental Protection Agency, Office of Research and Development.

Chestnut, L.G., R.D. Rowe and J. Murdoch. 1986. *Review of 'Establishing and Valuing the Effects of Improved Visibility in Eastern United States.'* Prepared for the U.S. Environmental Protection Agency. October.

Chestnut, L.G. and R.D. Rowe. 1990a. *Economic Valuation of Changes in Visibility: A State of the Science Assessment for NAPAP*. Section B5 in NAPAP State of Science and Technology Report 27.

Chestnut, L.G. and R.D. Rowe. 1990b. *Preservation Values for Visibility Protection at the National Parks*. Prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, and National Park Service, Air Quality Management Division.

Leggett, C.G. and J.E. Neumann. 2004a. *Responding to SAB Council Comments on the May 2003 Draft Analytical Plan for the Section 812 Second Prospective- Visibility Benefits.* Prepared for the U.S. Environmental Protection Agency, Office of Policy Analysis and Review. September.

Leggett, C.G., K.J. Boyle, R.C. Carson, R.E. Unsworth, J.E. Neumann, R.W. Paterson, and R.C. Mitchell. 2004b. *Valuing Visibility in National Parks: An Overview of the Challenges.* Prepared for U.S. National Park Service, Air Resources Division.

Loehman, E.T., D. Boldt and K. Chaikin. 1984. *Measuring the Benefits of Air Quality Changes in the San Francisco Bay Area*. Prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. October.

Loehman, E.T., S. Park, and D. Boldt. 1994. "Willingness to Pay for Gains and Losses in Visibility and Health." *Land Economics* 70(4): 478-498.

McClelland, G., W. Schulze, D. Waldman, J. Irwin, D. Schenk, T. Stewart, L. Deck and M. Thayer. 1991. *Valuing Eastern Visibility: A Field Test of the Contingent Valuation Method*. Prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation.

Rae, D.A. 1983. *Benefits of Visual Air Quality in Cincinnati Results of a Contingent Ranking Survey*. Prepared for Electric Power Research Institute. May.

Tolley, G., A. Randall, G. Blomquist, M. Brien, R. Fabian, G. Fishelson, A. Frankel, M. Grenchik, J. Hoehn, A. Kelly, R. Krumm, E. Mensah, and T. Smith. 1986. *Establishing and Valuing the Effects of Improved Visibility in Eastern United States*. Prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. U.S.EPA Grant #807768-01-0.