IEc

MEMORANDUM | 31 March 2009

TO Jim DeMocker, EPA OAR/OPAR

FROM Jim Neumann and Chip Paterson, IEc

SUBJECT Alternative Approach to Estimating Monetized Benefits of Residential Visibility for the Section 812 Second Prospective

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The purpose of this memorandum is to propose an approach to estimating benefits associated with improved urban or residential visibility conditions. Residential visibility refers to conditions in large metropolitan areas, cities, towns and associated views/landscapes that individuals interact with on a regular basis. In particular, residential visibility is distinct from recreational visibility, which refers specifically to conditions in Class I areas (e.g., certain NPS units and wilderness areas). While improved visibility conditions in Class I areas has been recognized in previous policy analyses, most recent benefits analyses do not quantify or monetize residential visibility improvements as part of the primary benefits estimates.

This memorandum consists of three sections. The first describes the policy and institutional background surrounding residential visibility valuation, including a summary of past work. The second section describes key considerations associated with residential visibility valuation. Finally, the third section describes our recommended approach to developing such values.

BACKGROUND

DEVELOPMENT OF CURRENT APPROACH TO RESIDENTIAL VISIBILITY

EPA has for many years conducted analyses of the effect of air pollution on visibility in both recreational and residential settings. Valuation of visibility improvements in the Section 812 series of studies has included both recreational and residential categories, though not in the same study. For example, the Retrospective study (USEPA 1997) valued visibility improvements throughout the country using a residential visibility approach based on results in the McClelland et al. (1991). The value applied was $14 (1990$) per household per deciview improvement in visibility.[1]

For the First Prospective study (USEPA 1999), EPA originally planned to evaluate both residential visibility and recreational visibility as part of the primary benefits estimate. The proposed approach for residential visibility would be based on the McClelland et al.

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[1] For further details see Appendix I: Valuation of Human Health and Welfare Effects of Criteria Pollutants in USEPA (1997), pages I-6 and I-7, and Table I-2. Unit Values for Economically Valuing Health and Welfare Endpoints, in particular entries for visibility valuation on page I-15.

research -- i.e., $17 (1997$) per household per deciview improvement. For recreational visibility, it was based on a new approach developed to support EPA's regional haze rules, using WTP values from the Chestnut and Rowe (1990) study -- i.e. $4.91 to $13.51 per household per deciview improvement (1997$) for households living outside of the region where a Class I area is located and $7.98 to $16.82 per household per deciview improvement (1997$) for households living in the region where a Class I area is located. The EPA Science Advisory Board for the First Prospective, however, recommended that the Agency place the residential visibility values in a screening level benefit category. Their rationale was that, "The McClelland et al. study was an exploratory study so the values found in it lack peer reviewed status. The authors, since 1990, have reduced their values by 50% to address the 'warm glow' effect found in similar studies and would reduce these quoted values by 50 percent presently to account for 'warm glow.' They [study authors] would not treat non-responses now as they did then, and this reduces the cited values by 20 percent. These two adjustments reduce the value to about $7.25 from $17." (USEPA SAB 1999).

Since this SAB review, all EPA air pollution benefits analyses, including the First Prospective, have adopted the approach of including recreational visibility values in the primary benefits estimates, but excluding residential visibility valuation from primary benefits and including it only as part of "sensitivity" analyses.

In the Second Prospective study, EPA proposed to value visibility in both recreational and residential settings, but to develop an "alternative estimate" for the residential visibility category based on the McClelland et al. (1991) research.[2] The rationale for this proposal was twofold: 1) The original enabling Clean Air Act Amendments language specifies that, "In any case where numerical values are assigned to…benefits, a default assumption of zero value shall not be assigned to such benefits unless supported by specific data."; and 2) In addition to the McClelland et al. study, there exist a wide range of published, peer-reviewed literature supporting a non-zero value for residential visibility. This memo is therefore consistent with the approach proposed in the 2003 Analytical Blueprint, but provides more detail on the details of the methodology.

RECENT RELATED REGULATORY DEVELOPMENTS

In December of 2005, the Office of Air Quality Planning and Standards (OAQPS) published *Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information* (the Staff Paper). OAQPS staff reviewed EPA's 2004 Criteria Document for PM and a variety of other studies of the effects of PM and its components on atmospheric visibility, and concluded that consideration should be given to revising the current suite of secondary $PM_{2.5}$ standards to provide "increased and more targeted protection primarily in urban areas from visibility impairment related to fine particles" (EPA 2005, p.7-12).

The staff first addressed the feasibility of valuing residential (or urban) visibility, citing the rapidly expanding national database of information on $PM_{2.5}$ in urban areas. OAQPS

[2] See Chapter 8, page 8-17 of the May 2003 *Benefits and Costs of the Clean Air Act 1990 - 2020: Revised Analytical Plan For EPA's Second Prospective Analysis*, available at: www.epa.gov/oar/sect812/blueprint.html

staff noted that the information gathered from the Automated Surface Observing System (ASOS), the largest instrument-based visibility monitoring network in the U.S., allows for updated characterizations of visibility trends and current levels in urban areas (EPA 2005, pp. 6-5, 7-4). The staff used these data to conduct a few preliminary analyses, and found that urban areas generally have higher loadings of $PM_{2.5}$ and, thus, higher visibility impairment than monitored Class I areas (EPA 2005, p.6-22). In addition, while annual average visibility conditions in Class I areas vary regionally across the U.S., residential visibility levels show far less difference between eastern and western regions (EPA 2005, p.7-5). This speaks to the feasibility of a national secondary standard for residential visibility.

OAQPS staff also reviewed the suite of techniques used by economists to quantify the economic benefits associated with visibility improvements in urban areas, focusing on contingent valuation and hedonic valuation. As an example, the staff cited a study conducted by Chestnut and Dennis in 1997, which analyzed the residential visibility benefits in the eastern U.S. due to reduced sulfur dioxide emissions under the acid rain program. The study authors derived an annual value of $2.3 billion (1994 dollars) in the year 2010. While recognizing identified concerns with valuation techniques, the paper states that EPA believes that well-designed and well-executed contingent valuation and hedonic valuation studies are useful for estimating the benefits of environmental effects such as improved visibility (EPA 2005, p. 6-15).

Finally, the Staff Paper noted that several state and local governments in the U.S. have developed programs to improve visibility in specific urban areas. These programs are based on surveys that use a series of slides to elicit citizens' judgments about the acceptability of different levels of visibility in urban areas using a series of slides. The most notable studies were conducted in Denver, Colorado, Phoenix, Arizona, and the province of British Columbia, Canada. These studies produced reasonably consistent results in terms of the visual ranges found to be generally acceptable by participants, ranging from 40 to 60 km (EPA 2005, p.7-5). OAQPS staff cite these regulatory and planning activities as being of particular interest because "they are illustrative of the significant value that the public places on improving visibility, and because they have made use of developed methods for evaluating public perceptions and judgments about the acceptability of varying degrees of visibility impairment" (EPA 2005, p.6-17).

OAQPS staff concluded that the findings of the new data analyses, in combination with recognized benefits to public welfare of improved visual air quality and an established approach for determining acceptable visual range, provide a basis for considering revisions to the secondary $PM_{2.5}$ standards to protect against PM-related visibility effects in urban areas (EPA 2005, p.6-23). The staff recommended ranges of alternative standards for the Administrator to consider in deciding whether to retain or revise the secondary PM NAAQS (EPA 2005, p.7-2).

The conclusions of the OAQPS staff paper were supported by the Clean Air Scientific Advisory Committee (CASAC) in two letters to EPA Administrator Stephen L. Johnson. In a letter dated March 21, 2006, CASAC wrote to express the views of the PM Panel (composed of the seven members of CASAC and fifteen technical experts) with regards to EPA's proposed revisions to the PM NAAQS. The letter requests that the sub-daily secondary standard to protect visibility, as recommended in the PM Staff Paper and by the CASAC, be favorably reconsidered (CASAC 2006a, p. 1-2).

In a second letter dated September 29, 2006, CASAC wrote to express concerns regarding the welfare implications of EPA's final secondary NAAQS for airborne PM. Noting that EPA's final rule on the NAAQS for PM does not reflect several aspects of the CASAC's advice, the letter states "the CASAC wishes to emphasize that continuing to rely on primary standards to protect against all PM-related adverse environmental and welfare effects assures neglect, and will allow substantial continued degradation, of visual air quality over large areas of the country" (CASAC 2006b, pp. 1-2).

PREVIOUS RESEARCH

Economic research on the value of improved visibility has been conducted since the late 1970s, beginning with Brookshire et. al.'s (1979) innovative comparison of hedonic and contingent valuation approaches in the Los Angeles area. Since that time several valuation studies of residential visibility improvements have been conducted (e.g., Loehman et al., 1984; McClelland et al., 1991; Rae, 1983 and Tolley et al., 1986). Exhibit 1 below summarizes features of the Brookshire, Loehman and Tolley studies.

While these studies have been criticized to varying degrees within the academic community and by stakeholder groups, the weight of evidence nonetheless suggests that the public values visibility improvements in residential settings. Valuation information from these studies is summarized in the next section.

In addition to valuation studies, several "preference" studies have been conducted for purposes of establishing visibility standards in urban areas. The first of these was conducted in Denver in response to call by the Colorado General Assembly in 1990 to establish a standard. The study focused on determining what visibility levels the public finds "acceptable" or "unacceptable." Survey respondents consisted of groups meeting for other purposes (e.g., church group, conservation committee) and a total of 17 groups (214 people) were surveyed. Respondents were shown slides taken from a visibility camera site between November 1987 and January 1988 that had suitable exposure and relative humidity less than 70%. Two sets of 25 slides were used and randomly and re-ordered for each group. Respondents were first asked to judge visual air quality (VAQ) on scale from 1 to 78 (very poor to excellent) and then to determine whether a given slide would violate the standard. Violations were defined as VAQ that is "unreasonable, objectionable, and unacceptable visually." Results indicated a high correlation of ratings with VAQ (around .9) and generally small differences across groups. The adopted standard, based on "50% acceptability," was 20.3 deciviews (a four-hour average between 8am and 4pm at relative humidity less than 70 percent).

EXHIBIT 1 **SUMMARY OF SELECTED VISIBILITY VALUATION STUDIES**			
STUDY	**LOCATION**	**SURVEY MODE & YEAR**	**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.

The second perception study was conducted in Vancouver, British Columbia. Approximately 200 students from the UBC Department of Geography were shown scenes of the Fraser Valley from the summer of 1993 taken by cameras at the Abbotsford Airport and Chilliwack hospital. Participants were asked to rank 26 randomly-ordered slides on a scale of 1 to 7 and then consider whether each slide would violate a standard ("how much haze or visibility degradation is too much?"). Slides were selected from those taken at noon and 3pm and which showed more than 2/10 and less than 9/10 cloud cover (to reduce the effect of variable illumination and sun angle). In addition, slides with greater than 75% humidity were eliminated. Similar to the Denver study, high correlation between ratings and visibility measures were observed (.88 to .93 across groups). In this case the standard (again based on median acceptability) was approximately 19 to 23 deciviews.

The third, and most recent, study was conducted in Phoenix, Arizona in 2002. Respondents were recruited randomly to 27 different sessions (385 respondents total) in six different locations in the Phoenix metropolitan area. They were shown 25 slides of the same scene, a southwestern perspective on the downtown area with South Mountain 25 miles in the distance. The WinHaze program was used to generate a range of visibility conditions from 15 to 35 deciviews, which reflects actual conditions in Phoenix. Respondents were asked to rate the scenes on a scale of 1 to 7, determine whether each scene was acceptable or not, and finally to indicate the number of days in a year that that scene would be acceptable. Here the standard was roughly 24 deciviews.

DEVELOPMENT OF RESIDENTIAL VALUES

KEY CONSIDERATIONS

A fundamental issue with respect to visibility valuation is whether estimated values reflect only visibility conditions and do not include other perceived benefits such as health or ecological improvements. Similarly, it is important to try to distinguish residential from recreational visibility- that is, can these be treated as distinct and additive benefit categories based on the available literature? In our selection of underlying valuation studies and recommended approach, we attempt to address both of these issues.

From the standpoint of feasibility of applying the method, the Project Team currently has air quality and visibility (deciview) data for the full 48-state CMAQ domain. In addition, we have shapefile and county classifications for Class I areas to support recreational visibility estimates. The gridded CMAQ data can also be resolved to the county or MSA level as needed. The visibility data are currently summarized as annual and quarterly averages, but the underlying daily averages could also be recovered from the primary dataset.

SUMMARY OF RECOMMENDED APPROACH

We propose two alternatives to valuing residential visibility improvements, as detailed in the attached memorandum (Paterson, Neumann, Leggett, 2005). Both rely upon a benefit transfer approach, drawing upon information from the published Brookshire, Loehman and Tolley studies. Specifically, 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. While uncertainty exists regarding the precision of these older, stated-preference residential valuation studies, we believe their results support the argument that individuals have a non-zero value for residential visibility improvements.

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)]

To demonstrate, 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.

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.

To estimate visibility benefits in locations other than those considered in the three studies, we propose transferring the *b* parameters from the eight study areas based on geographic proximity. In particular, we consider two scenarios. In one scenario we assume that residential and recreational visibility benefits are distinct and separable. Under this approach residential values from the existing literature are transferred to all Metropolitan Statistical Areas (MSAs) in the conterminous U.S. In the second scenario we assume that the recreational values from Chestnut and Rowe (1990) implicitly include residential values - therefore for the second option we exclude all MSAs in California, the Colorado Plateau and the Southeast.

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

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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.

Ely, D.W., J.T. Leary, T.R. Stewart and D.M. Ross. 1991. The Establishment of the Denver Visibility Standard. For Presentation at the 84th Annual Meeting of the Air and Waste Management Association, Vancouver BC, June.

Chestnut, L.G. and R.D. Rowe. 1990. 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.

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Clean Air Scientific Advisory Committee (CASAC). Letter to EPA Administrator Stephen L. Johnson. September 29, 2006b. EPA-CASAC-LTR-06-003, available at: http://yosemite.epa.gov/sab/sabproduct.nsf/1C69E987731CB775852571FC00499A10/$File/casac-ltr-06-003.pdf

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.

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.

Pryor, S.C. 1996. Assessing Public Perception of Visibility for Standard Setting Exercises. *Atmospheric Environment*. 30(15).

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.

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U.S. Environmental Protection Agency. (1997) *The Benefits and Costs of the Clean Air Act: 1970 to 1990.* Report to Congress.

Attachment A:

IEc's August 2005 methods memorandum

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:

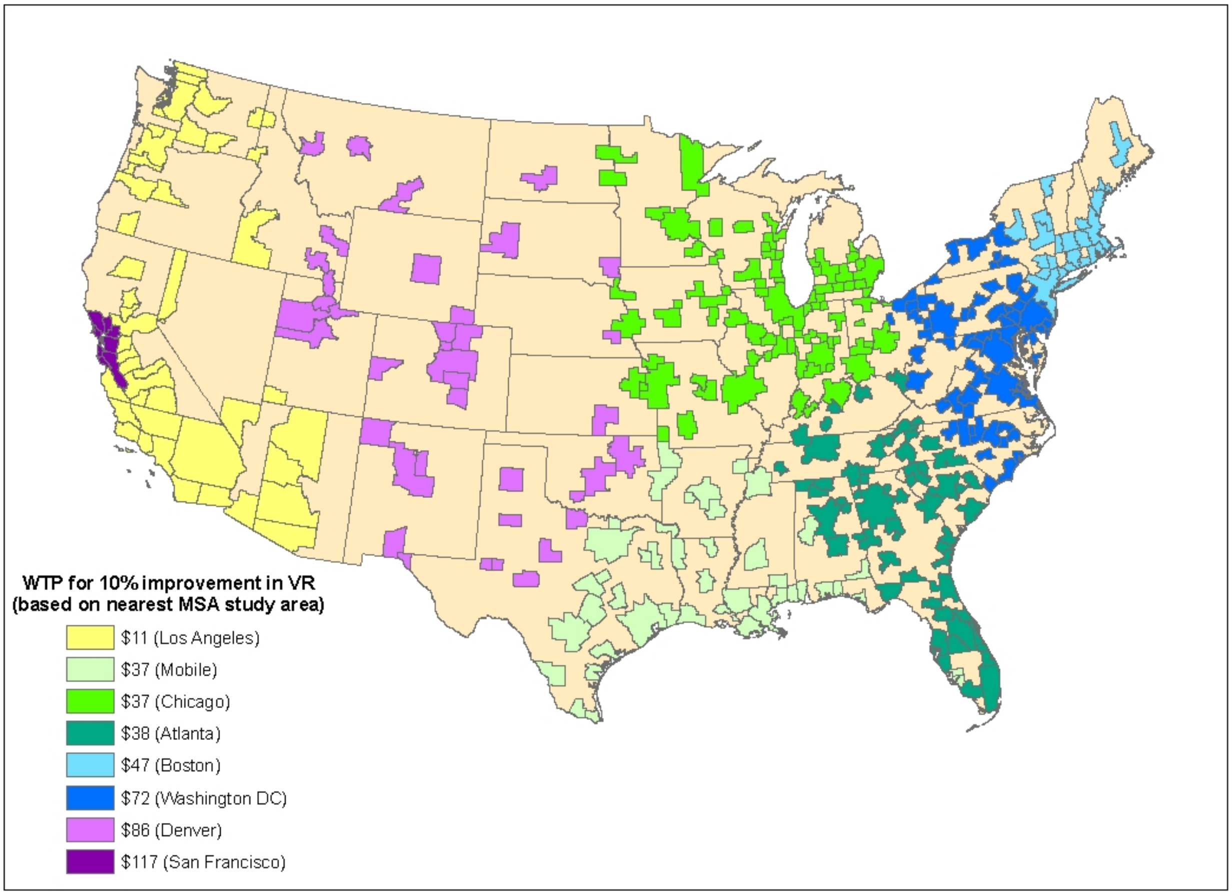
Scenario 1: Transfer to all MSAs

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.

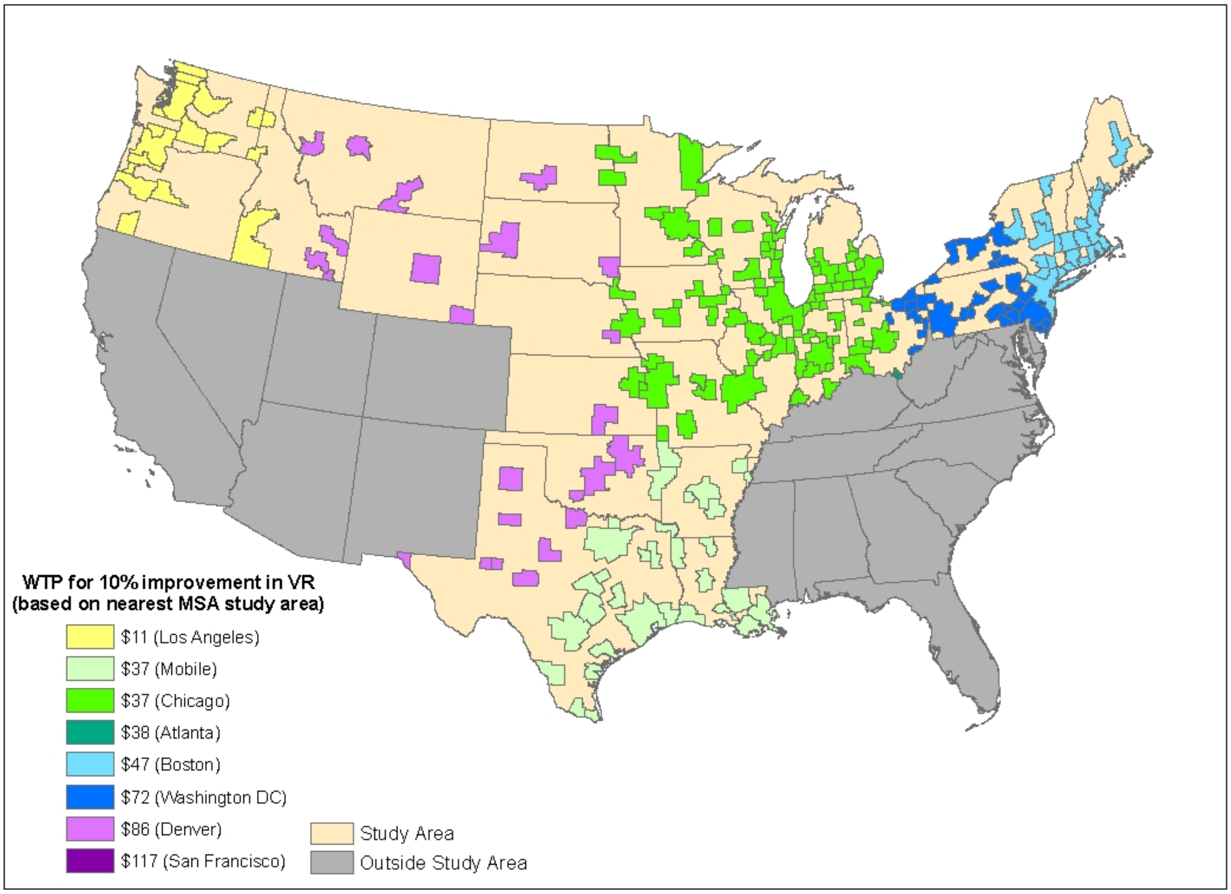
Figure 1. MSAs with Assigned Residential Visibility Values



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.

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Attachment B:
IEc's September 2004 Methods Memo

MEMORANDUM

30 September 2004

TO: Nona Smoke, EPA/OPAR

FROM: Chris Leggett and James Neumann, IEc

CC: James DeMocker, EPA/OPAR and Bryan Hubbell, EPA/OAQPS

SUBJECT: Responding to SAB Council Comments on the May 2003 Draft Analytical Plan for the Section 812 Second Prospective – Visibility Benefits

Under Section 812 of the Clean Air Act Amendments, EPA is requested to periodically conduct and submit to Congress a report on economic benefits and costs of all provisions of the Act and its Amendments. EPA delivered the first of these reports, a retrospective analysis covering provisions of the original Clean Air Act during the period 1970-1990, in 1997, and the second report, a prospective analysis covering provisions of the Amendments during the period 1990-2010, in 1999.

EPA is currently working on the third report to be developed under Section 812. This "Second Prospective" report will estimate benefits and costs for provisions of the Amendments as they are expected to be implemented during the period 1990-2020. An analytical plan for the Second Prospective was completed in May 2003, and comments from the SAB Council reviewing the plan were received by EPA in May 2004.[1]

1 The May 2003 Analytical Blueprint for the second prospective study, along with a complete copy of the first prospective Report to Congress, can be found on EPA's web site at: http://www.epa.gov/oar/sect812/. The SAB Council's comments on the May 2003 Analytical Blueprint can be found at: http://www.epa.gov/sab/pdf/council_adv_04004.pdf and http://www.epa.gov/sab/pdf/council_adv_04_001.pdf .

This memorandum addresses one of the key issues raised in the SAB Council comments, the valuation of visibility improvements. The memorandum includes three sections: an evaluation of the potential usefulness of hedonic property value studies for estimating residential visibility values, a description of our recommendation for valuing residential visibility, and an evaluation of the potential usefulness of the Smith and Osborne (1986) meta-analysis to evaluate visibility benefits for eastern and western parks. We do not evaluate the ongoing EPRI research on recreational visibility valuation in the current memorandum (as was recommended by the Council), as the results of this work are not yet publicly available.

In summary, our conclusions are as follows:

- In order to assess the validity of the results from hedonic property value studies, we recommend that the Agency conduct a focused investigation in Los Angeles designed to determine whether market participants are aware of spatial variation in visibility, take this variation into account when purchasing a home, and consider visibility separately from the health effects of air pollution. Until such an investigation has been undertaken, we do not recommend that the Agency use the results from hedonic property value studies to value residential visibility improvements. If the investigation determines that the visibility benefit estimates from the hedonic property value studies are indeed valid, then we recommend that the Agency apply these values to evaluate residential visibility benefits.

- If confirmatory evidence from this focused investigation cannot be obtained, then we recommend combining the results from several contingent valuation (CV) studies to assess the value of residential visibility. Each of the existing contingent valuation (CV) studies that focus on residential visibility has a variety of design flaws, and all of the studies are somewhat dated with respect to methodology. Nonetheless, the Council recommends that the Agency re-examine existing studies to evaluate their potential for use in estimating residential visibility benefits. After reviewing these studies, it is our opinion that several can provide reasonable estimates of residential visibility benefits.

- We do not recommend that the Agency use the Smith and Osborne (1986) study to evaluate the benefits of recreational visibility improvements due to ambiguity regarding the commodity valued in the Osborne and Smith (1986) WTP function, as well as ambiguity regarding the population that values the commodity.

The Use of Hedonic Property Value Studies to Evaluate Residential Visibility Benefits

The Council recommends that the Agency evaluate available studies addressing residential visibility and develop an approach for including residential visibility in the primary benefit estimates. In particular, the Council suggests that the Agency consider the possibility of using hedonic property value models for residential visibility estimates.

We have reviewed available hedonic property value studies that focus on residential visibility (i.e., Beron, Murdoch, and Thayer, 2001; Murdoch and Thayer, 1988; and Trijonis et al., 1985) as well as recent evidence from hedonic property value studies examining the impact of air pollution on property values (i.e., Zabel and Kiel, 2000; Chay and Greenstone, 2000; Chattopadhyay, 1999; Smith and Huang, 1995). Our conclusion from this review is that although hedonic property value studies provide important empirical evidence that clean air appears to be capitalized into housing values in some metropolitan areas, the Agency should not use the results from these studies to develop quantitative estimates of the benefits of visibility improvements without further study. The remainder of this section describes the basis for this conclusion and outlines our recommendations for further study.

Hedonic property value studies rely on a statistical analysis of price differences in the residential housing market in order to make inferences about residents' WTP for a particular amenity, holding other factors constant. A number of conditions must be satisfied in order for a hedonic property value study to provide a defensible estimate of WTP for visibility improvements:

1. There must be spatial variation in visibility within the study area.

2. Individuals must be aware of the variation in visibility.

3. Individuals must care enough about differences in visibility that they take them into account when purchasing a house.

4. Individuals must care about visibility for aesthetic reasons rather than viewing visibility as a proxy for other impacts associated with air pollution, such as health effects.

Condition #1 must be satisfied to statistically evaluate the impact of visibility. The existence or absence of sufficient spatial variation in visibility will be a function of the locations of emissions sources, topography, and atmospheric conditions. If these factors vary sufficiently within a single metropolitan area, then this condition is likely to be satisfied. For example, Trijonis et al. (1984) demonstrate that there is substantial variation in median visual range across the Los Angeles area, and that the spatial pattern of visibility was relatively constant over time.

Conditions #2 and #3 must be satisfied if this spatial variation in visibility is to be reflected in housing prices. As noted by Zabel and Kiel (2000), "Underlying the analysis of the valuation of air quality is the notion that individuals perceive the pollution level in their neighborhood and place a value on this level through the amount they are willing to pay for their house" (p. 192). If researchers obtain a positive coefficient on the visibility measure in a hedonic property value study when conditions #2 and #3 are not satisfied, then the measure must be correlated with a relevant characteristic that was omitted from the analysis. The requirement that individuals be aware of differences in visibility is more difficult to satisfy than it may at first appear. This is much more difficult than, for example, asking whether an individual will notice a difference in visibility when looking at two different photographs of the same scene. First, visibility changes from day to day, so individuals must be capable of processing information about the distribution of visibility in a particular neighborhood and comparing this to visibility distributions in other neighborhoods. Second, the background scenery differs across neighborhoods so that it may be difficult, for example, to compare visibility in a neighborhood that has a view of distant mountains with visibility in a neighborhood that has a view of the city skyline.

The existing literature provides limited empirical evidence that individuals are aware of differences in visibility and take these differences into account when planning to move. In one of the first hedonic property value studies focused on air pollution, Ridker and Henning (1967) report that there is “some evidence from questionnaires that people believe air pollution affects property values and that it sometimes figures in their calculations in planning to move” (p. 246). However, it is not at all clear that this statement would still be true today, after several decades of substantial improvements in air quality. More recent hedonic property value studies (e.g., Trijonis et al., 1984; Chattopadhyay, 1999; Zabel and Kiel, 2000; Beron, Murdoch, and Thayer, 2001) have failed to provide any direct evidence that market participants are aware of spatial differences in air pollution or that their decision to purchase a house is affected by these differences.[5,6] Without such evidence, the possibility of omitted variables bias cannot be ruled out. Kenneth Small (1974) alludes to this possibility in an early comment on the validity of the hedonic property value technique as applied to air pollution: “I have entirely avoided…the important question of whether the empirical difficulties, especially correlation between pollution and unmeasured neighborhood characteristics, are so overwhelming as to render the entire method useless” (p. 107).

Finally, given the structure of the Section 812 benefits analysis and other regulatory analyses, where health effects are evaluated separately from aesthetic effects, condition #4 requires that any observed response to visibility be linked to aesthetic concerns rather than concerns about health. Otherwise, health benefits would be double counted in the benefits analysis. Unfortunately, the visibility valuation literature indicates that individuals have trouble separating visibility from other impacts of air pollution (e.g., McClelland et al., 1991; Chestnut and Rowe, 1990; Carson, Mitchell, and Ruud, 1990). Thus, even if the spatial variation in visibility is reflected in housing, caution is required in interpreting the coefficient on visibility: it is entirely possible to obtain a positive coefficient on visibility simply because market participants believe that poor visibility is an indicator of hazardous air pollutants.

Although several hedonic property value studies conducted in the Los Angeles area have found a statistically significant association between visibility and property values (Beron, Murdoch, and Thayer, 2001; Beron, Murdoch, and Thayer, 1999; Murdoch and Thayer, 1988; and Trijonis et al., 1985), none of these studies provides evidence that conditions #2, #3, and #4

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[5] In a CV study focused on the visibility and health effects of air pollution, Loehman, Boldt, and Chaikin (1984) find that in the San Francisco area, residents’ own estimates of the number of high-visibility days that they experience per year are higher for respondents living in areas that do, in fact, have better visibility. Although this result is encouraging, it does not demonstrate that respondents are aware of visibility levels in areas other than where they currently live.

[6] Brookshire et al. (1979) include several simple questions in their survey of Los Angeles residents that address this issue (e.g., “Has air pollution influenced where you have chosen to live?” and “Would you consider moving to a new location in the Los Angeles area if air quality were like Picture C everywhere?”), but they do not discuss the responses to these questions in their report. Similarly, Loehman, Boldt, and Chaiken (1984) include several choice experiment-type questions focused on housing purchase decisions (the attributes were number of bedrooms, air quality, traffic, commuting time, and cost) in their survey of San Francisco area residents, but they do not analyze the responses to these questions.

were satisfied. Thus, we recommend that the Agency proceed with caution in using residential visibility values from the hedonic property value literature. Unless research provides support for the assumption that market participants are aware of spatial variation in visibility, consider this variation when purchasing a home, and can successfully separate visibility effects from health effects, empirical evidence of the impact of visibility on property values should not be used to make inferences regarding individuals' WTP for visibility.

However, the recent Beron, Murdoch, and Thayer (2001) study does show substantial promise. This study investigates the determinants of sales price for approximately 840,000 residential homes in the Los Angeles area that sold between 1980 and 1995. In addition to a variety of structural and neighborhood characteristics, the researchers include measures of ozone, total suspended particulates, and visibility (mean annual visual range) as independent variables. Visibility was found to have a significant impact on housing values, with a one-mile increase in average visibility adding approximately $5,000 to the value of a home. Results from a second-stage analysis indicate that household WTP for a three-mile (20 percent) increase in mean visibility ranges from approximately $1,000 to $3,000 per year.

Given the strength of the Beron, Murdoch, and Thayer research and OMB's preference for revealed preference studies (OMB, 2003), we recommend that the Agency carry out a focused investigation designed to determine whether the Beron, Murdoch, and Thayer study is likely to satisfy the conditions listed above for hedonic property value studies. This investigation would comprise the following steps:

- Obtain a list of licensed realtors in the Los Angeles area from the National Association of Realtors and conduct phone interviews with a random sample of approximately 10 to 20 realtors from this list. Determine the extent to which the realtors' clients are aware of spatial variation in visibility, the frequency with which clients inquire about visibility levels in specific areas, and the extent to which clients draw a distinction between visibility and health when they discuss air pollution issues.

- Organize and conduct focus groups with recent homebuyers in the Los Angeles area in order to further evaluate the above issues. The focus groups are necessary because individuals may be aware of and care about spatial variation in visibility but not discuss the issue with their realtor when purchasing a home. One set of focus groups (two groups with nine individuals in each groups) could be conducted in an area with relatively poor visibility, while the other set of focus groups (two groups with nine individuals in each group) could be conducted in an area with relatively good visibility.

If this investigation indicates that Los Angeles area residents do indeed consider visibility levels when purchasing a home, and if visibility appears to be important for aesthetic (rather than health) reasons, then we would recommend that the Agency consider using the Beron, Murdoch, and Thayer study to evaluate residential visibility benefits. Furthermore, in order to obtain residential visibility values for other metropolitan areas, the Agency may want to consider possibilities for introducing visibility variables in recent hedonic property value studies (e.g., Zabel and Kiel, 2000; Chattopadhyay, 1999). This would allow the Agency to obtain primary estimates of visibility benefits for cities other than Los Angeles by taking advantage of high-quality, pre-existing datasets.

Recommendation for Using CV Studies to Evaluate Residential Visibility Benefits

The Council recommends that the Agency revisit available contingent valuation studies that investigate the benefits of improvements in residential visibility. We identified five contingent valuation studies that have investigated individuals' WTP for improved visibility in urban areas[7]:

- Brookshire et al. (1979) conducted an in-person survey of Los Angeles area residents. Respondents were shown three photographs of local vistas representing "poor," "fair," and "good" visibility conditions, corresponding to visual ranges of 2, 12, and 28 miles, respectively. The vista used to depict poor visibility differed from the vista used to depict fair and good visibility. Respondents were asked if they would be willing to pay a specific monthly fee in order to achieve improved visibility conditions (e.g., an improvement from "fair" to "good"). The question asked them to focus only on visibility.

- Rae (1983) conducted a survey of Cincinnati residents at a central location (participants were recruited by telephone). The visibility levels were depicted using three different projected slides of the same scene, with visual ranges of 3 miles, 12 miles, and 17 miles. Respondents completed a contingent ranking exercise, where they were asked to rank nine different combinations of visibility (percentage of days per year with each of three visibility levels), fuel costs, thermostat settings, and health effects (number of days per year with eye and lung irritation).

- Loehman, Boldt, and Chaikin (1984)[8] conducted in-person interviews with residents of the San Francisco Bay area. Respondents were shown nine separate photographs depicting three different Bay-area vistas under three different visibility conditions (clear – visual range > 10 miles, moderate – visual range 6-10 miles, and poor – visual range < 5 miles). Respondents were asked for their WTP for a specific change in the number of days per year under each of the three visibility conditions. In an attempt to control for perceived health improvements, each CV question also specified the number of days per year under five different health conditions (good, moderate, unhealthy, very unhealthy, or hazardous) before and after the visibility improvement.

[7] We identified two additional studies that focus on residential visibility: Irwin et al. 1990 and Carson, Mitchell, and Ruud (1990). These were pilot studies and consequently are not considered in the discussion below.
[8] Results later published as Leohman, Park, and Boldt (1994).

- Tolley et al. (1986) conducted in-person interviews with residents of Atlanta, Boston, Chicago, Cincinnati, Denver, Miami, Mobile, and Washington D.C. Respondents were shown three separate photographs depicting three different visual ranges (the visual ranges differed across cities).[9] The three different visual ranges were produced by air brushing a single negative. The CV question asked respondents for their WTP for a 10- and 20-mile improvement in average visual range, and for their WTP to avoid a 5-mile decrease in average visual range. The question asks respondents to focus on visibility rather than health.

- McClelland et al. (1991) conducted a mail survey of residents of the Atlanta and Chicago metropolitan areas. Each respondents was shown nine different photographs, representing three scenes (skyline, residential, and park) under three different visual ranges (5, 15, and > 40 miles). The different visual ranges were developed by digitally altering the photographs. Respondents were asked for their WTP for 25 additional days per year with visual range of > 40 miles and 25 fewer days per year with visual range of 5 miles. The CV question indicates that there would be health impacts in addition to the visibility change, and a follow-up question asks respondents to allocate WTP to visibility, health, materials soiling, vegetation impacts, and other impacts.

As there are no universally accepted criteria for evaluating contingent valuation studies, it is difficult to evaluate the potential usefulness of these five studies for policy analysis. All of the studies were led by experienced economists and represent major efforts to value residential visibility. Nonetheless, previous evaluations of residential visibility benefits conducted by the Agency have discarded the four older studies in favor of the McClelland et al. (1991) research. A re-examination of the five studies indicates, however, that every one of the five studies could be criticized along several dimensions, and it is not at all clear that the McClelland et al. work is superior to the others (Exhibit 1).

In light of the Council's recommendation that the agency should "review the available studies, revisiting the older ones and adding the newer ones," we recommend that the Agency use Brookshire et al. (1979), Loehman, Boldt, and Chaikin (1984), and Tolley et al. (1986) to develop values for residential visibility. We do not recommend using the McClelland et al. (1991) study due to concerns expressed by a previous Council. In an October 29, 1999 letter to Carol Browner, the Council states: "The McClelland et al. study was an exploratory study, so the values found in it lack peer reviewed status…the Council believes that it is inappropriate to use their study values." We do not recommend using the Rae (1983) study as this study represents one of the first attempts to apply a choice question approach to valuation; the state-of-the-art has evolved substantially since the study was conducted. In particular, it is not clear that respondents can effectively process information about, and rank, nine different programs defined by varying levels of four characteristics. Furthermore, the Rae study was conducted in Cincinnati, a city that is covered by the Tolley et al. research.

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[9] Tolley et al. (1986) conducted two separate surveys. The main survey was conducted in 1982 in Atlanta, Boston, Cincinatti, Miami, Mobile, and Washington D.C. and included photographs from Chicago. A follow-up survey was conducted in 1984 in Atlanta, Chicago, and Denver and included photographs from the respondent's local city.

Exhibit 1 CV Studies that Focus on Residential Visibility	
Study	**Potential Disadvantages for Use in Evaluating Residential Visibility Benefits**
Brookshire et al. (1979)	• Did not hold atmospheric conditions and scenery constant in presenting photographs representing different visibility levels. • Effort to convince respondent to focus only on visibility (rather than health) was somewhat weak. No follow-up questions investigated the extent to which this effort was successful. • No budget reminders or reminders of substitute commodities.
Rae (1983)	• Study is extremely early version of choice experiment approach to valuation; this methodology has evolved significantly since the study was completed. • No budget reminders or reminders of substitute commodities. • Study results were not published in peer-reviewed journal.
Loehman, Boldt, and Chaikin (1984)	• The mechanism that would lead to the air quality improvement was not described to the respondent. • No budget reminders or reminders of substitute commodities.
Tolley et al. (1986)	• The CV question asked about changes in visibility that were somewhat different from the changes presented in the photographs. • In the 1982 survey, the photographs used to depict visibility changes were not from the respondent's city. • The mechanism that would lead to the air quality improvement was not described to the respondent. • Despite a strong effort to convince respondents to focus only on visibility, no follow-up questions investigated the extent to which this effort was successful. • Payment vehicle was not specified in the 1982 survey. • Study results were not published in peer-reviewed journal.
McClelland et al. (1991)	• *Ex post* allocation of WTP assumes that the utility function is additively separable in visibility and health, which may not be true. • The CV question allows for potential health effects (along with visibility effects), but it does not describe these effects to the respondent. • NOAA panel (Arrow et al., 1993) and Mitchell and Carson (1993) recommend in-person surveys rather than mail surveys for contingent valuation research. • Only 31 percent overall response rate (survey response rate X CV question response rate). • No budget reminders or reminders of substitute commodities. • Study results were not published in peer-reviewed journal. • Analysis appears to have been truncated; no final report was produced.

The Loehman, Boldt, and Chaikin (1984) and Brookshire et al. (1979) studies were published in peer-reviewed journals (Loehman, Park, and Boldt, 1994; Brookshire et al., 1982). The Tolley et al. (1986) work was not published in a peer-reviewed journal, but it was subject to peer review during the development of the study.

The Tolley et al. (1986) study has been criticized for using photographs of Chicago scenes to describe various levels of visibility to residents of other cities, and for having a CV question focused on visibility improvements that differed somewhat from the visibility changes presented in the accompanying photographs. We do not believe that these are fatal design flaws for the study. Presenting Chicago photographs to residents of other cities is simply an extreme version of a problem that exists in *all* stated preference valuation studies focused on visibility. That is, the photographs that the researcher presents to the respondent cannot perfectly reflect the typical views that the respondent sees and cares about. As a result, the respondent must mentally transfer the visibility conditions in the photos to the views and vistas that he or she cares about and is accustomed to seeing in everyday life. The presentation of views from a different city (rather than, for example, a different neighborhood) may or may not make this mental transfer more challenging. Having a CV question with visibility improvements that differ from the visibility changes in the photographs also may complicate the decision process for the respondent, but the extent of the complication is not clear. Essentially, the researcher is now requiring the respondent to mentally interpolate between photographs displaying identical scenes with different visual ranges, a task that is likely to be much less difficult than determining one's WTP for an unfamiliar commodity such as visibility.

For a variety of reasons, one would expect that residential visibility would differ from region to region and from city to city, and these differences should be taken into account in evaluating residential visibility benefits. In addition to different baseline levels of visibility, different weather conditions, and different resident characteristics, different locations provide dramatically different vistas. For example, one would expect that residents of Denver, with a dramatic view of the Rocky Mountains that is rarely obstructed by trees, would have a greater interest in protecting visibility than residents of Nashua, New Hampshire, a city without a dramatic skyline or nearby mountains and with numerous trees obstructing vistas in residential areas. Fortunately, the three recommended studies provide primary visibility values for a variety of cities throughout the United States: Atlanta, Boston, Chicago, Cincinnati, Denver, Los Angeles, Miami, Mobile, San Francisco, and Washington D.C.

In order to use the visibility values from the three studies to evaluate the benefits of visibility improvements throughout the U.S., we recommend calibrating a separate WTP function for each city that is similar to the function used in the First Prospective analysis:

$$WTP = b * \frac{\ln VR2}{\ln VR1}$$

where:

VR2 = mean annual visual range after the improvement,
VR1 = mean annual visual range before the improvement, and
b = parameter.

The entire contiguous United States would be divided into ten mutually exclusive regions based on geographic proximity to the ten cities listed above. For each region, the *b* parameter from the closest city would be used to evaluate residential visibility benefits. We recommend that the Agency develop an approach to adjusting for differences in income using information from the above studies on the income elasticity of WTP. The Agency currently adjusts for income differences in evaluating recreational visibility benefits. Recreational and residential visibility are very different goods however, and it is entirely possible that the income elasticity of WTP for residential visibility differs from the income elasticity of WTP for recreational visibility. In particular, we note that the cost of travelling to distant national parks is quite high, so that high-income households (who are more likely to be able to afford a visit) may be WTP much more than low-income households to protect visibility in these locations. Residential viewing experiences are comparatively inexpensive, so that income may play a less significant role in determining WTP for residential visibility.

In order to avoid potential overlap with the recreational visibility estimates, we recommend that residential visibility benefits not be estimated for the regions evaluated in the Chestnut and Rowe (1990) study of recreational visibility: California, the Southwest, and the Southeast. In these areas, residents were asked about their WTP for visibility improvement at national parks and wilderness areas in the region that they currently live in. However, due to atmospheric mixing, emissions reductions that impact national parks and wilderness areas are also likely to impact residential areas in the same region. We suspect that many of survey respondents would realize this and, as a result, some portion of their bid on the CV question would likely be associated with a desire to improve residential visibility.

In the previous section, we argued that the visibility variable in a hedonic property value study may reflect more than preferences for visibility if market participants see visibility levels as indicators of health effects. Similarly, CV studies designed to value visibility improvements must successfully separate respondents' preferences for visibility from their preferences for health. The three CV studies that we recommend accomplish this objective in somewhat different ways.[10] Tolley et al. (1986) specify a hypothetical pollution control program that will *only* affect visibility: "Suppose a program could be set up to prevent the decline in visibility, realizing that there would be no health effects." In contrast, Brookshire et al. (1979) specify a more general pollution control program, but they ask respondents to focus only on their preferences for visibility improvements: "I am only interested in how you value being able to see long distances." Finally, Loehman, Boldt, and Chaikin (1986) present summary tables to respondents that describe the expected number of days per year at various health and visibility levels for both the baseline and the improved situations. Respondents are asked to provide WTP for air quality improvements with an increased number of good visibility days but with health levels held constant.

The degree to which the three studies were successful in convincing respondents to focus solely on visibility is unclear, as none of the three studies includes follow-up questions necessary to investigate the issue. Furthermore, no other residential visibility CV studies provide evidence regarding the degree to which health effects are embedded in visibility values. Although the

[10] See Leggett et al. (2004) for a more detailed discussion of this issue.

McClelland et al. (1991) study has a follow-up question designed to allocate WTP across several categories, the CV question in the McClelland et al. study was focused on air pollution generally rather than visibility. As a result, we do not recommend that the Agency adjust the results from these studies to account for potentially embedded health effects.

Use of the Smith and Osborne (1996) Meta-Analysis

The Council recommends that the Agency consider using the Smith and Osborne (1996) meta-analysis to evaluate visibility benefits for eastern and western parks. The Smith and Osborne (1996) meta-analysis combines information from five different contingent valuation studies (Rowe, d'Arge, and Brookshire, 1980; MacFarland, Malm, and Molenar, 1983; Schulze et al., 1983; Chestnut and Rowe, 1990; and Balson et al., 1990) to estimate a visibility WTP function. All five studies focus on visibility improvements in national parks. The dependent variable for the analysis is the log of mean WTP, while independent variables include the percentage change in visual range, as well as a variety of indicator variables related to the commodity definition and study design.

We do not recommend that the Agency use the Smith and Osborne study to evaluate the benefits of recreational visibility improvements. Our concern is that the Smith and Osborne WTP function does not clearly define either the commodity to be valued or relevant household characteristics. Thus, although the Smith and Osborne study represents a creative attempt to combine information from five visibility valuation studies for the purpose of evaluating sensitivity to scope, we do not believe the results would be suitable for policy analysis. The remainder of this section elaborates on these points.

The Smith and Osborne (1996) meta-analysis combines values from studies that investigate preferences for different commodities. Although all of the studies investigate WTP for visibility improvements at national parks, each of the studies makes very different assumptions regarding the specific *geographic region* within which this visibility improvement would occur (Exhibit 2). Smith and Osborne include two explanatory variables that allow the commodity definition to depend on the geographic region. One variable allows WTP for visibility to differ for national parks located in the East. A second variable allows WTP to differ if the visibility change occurs over an entire region rather than in a specific park.. Clearly, these two variables do not reflect the diversity of geographic areas addressed in the underlying studies, and the result is a function that captures WTP for visibility improvements in some undefined combination of these areas. The lack of specificity would make it difficult to use the Smith and Osborne WTP function to value visibility changes in specific geographic areas.

Furthermore, the degree to which respondents were valuing health improvements in addition to visibility improvements is likely to differ across the five studies, and this issue is not addressed in the Smith and Osborne meta-analysis. For example, the Chestnut and Rowe (1990) CV question encouraged respondents to separate WTP for visibility improvements from WTP for health and ecological improvements. The introduction to their CV question states that "These questions concern only visibility at national parks in the Southwest…other households are being asked about visibility, human health and vegetation protection in urban areas and at national parks in other regions" [emphasis in original]. Despite this explicit focus on visibility in the CV question, a follow-up survey question indicated that nearly two-thirds of the respondents believed that their payment would provide more than just visibility improvements at national parks. The Schulze et al. (1983) CV question is likely to have induced hypothetical payments that were even less focused on visibility. The introduction to their CV question states that if "the current emission standards for sulfur oxide are not enforced, then average air quality and visibility in the region will become like Column B" [emphasis added]. Given the difficulty involved in designing a CV question that will encourage respondents to focus exclusively on visibility improvements (as opposed to health and ecological improvements), and given the dramatic differences in CV question wording across the five studies, it is very likely that the degree to which these effects confound WTP for visibility differs across the five studies.

Exhibit 2
Geographic Area Of Proposed Visibility Improvement In Studies Used In Smith And Osborne (1996) Meta-Analysis

Study	**Geographic area where proposed visibility improvement occurs**
Rowe, d'Arge, and Brookshire (1980)	Four Corners Region of Southwest
MacFarland, Malm, and Molenar (1983)	Grand Canyon and Mesa Verde National Parks
Schulze et al. (1983)	Grand Canyon National Park and the Southwest Parklands Region (two separate CV questions)
Chestnut and Rowe (1990)	National parks in the Southwest, Southeast, and California (separate CV questions for each region)
Balson et al. (1990)	Grand Canyon National Park

Our second concern with using the Smith and Osborne analysis is that the WTP function does not specify the characteristics of households that would be willing to pay for visibility. The WTP estimates taken from the five different studies represent a wide variety of target populations (Exhibit 3). Smith and Osborne include two explanatory variables that address characteristics of these populations. The first is a variable that indicates whether the study involved an on-site survey of national park visitors. The second is a variable that indicates whether the respondents are residents of the state in which the park is located. These two variables do not reflect potentially important characteristics of the underlying populations, such as income.

Exhibit 3 Target Populations For Studies Used In Smith And Osborne (1996) Meta-Analysis	
Study	**Target population**
Rowe et al. (1980)	Residents of Farmington, New Mexico and visitors to Navajo Reservoir
MacFarland et al. (1983)	Visitors to Grand Canyon and Mesa Verde National Parks
Schulze et al. (1983)	Residents of Albuquerque, Los Angeles, Denver, and Chicago
Chestnut and Rowe (1990)	Residents of Arizona, Virginia, California, New York, and Missouri
Balson et al. (1990)	Residents of St. Louis and San Diego Counties

Appendix B

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Albany, GA	Atlanta	401.4	Tolley et al.	No
Anderson, SC	Atlanta	401.4	Tolley et al.	No
Anniston-Oxford, AL	Atlanta	401.4	Tolley et al.	No
Asheville, NC	Atlanta	401.4	Tolley et al.	No
Athens-Clarke County, GA	Atlanta	401.4	Tolley et al.	No
Atlanta-Sandy Springs-Marietta, GA	Atlanta	401.4	Tolley et al.	No
Auburn-Opelika, AL	Atlanta	401.4	Tolley et al.	No
Augusta-Richmond County, GA-SC	Atlanta	401.4	Tolley et al.	No
Birmingham-Hoover, AL	Atlanta	401.4	Tolley et al.	No
Bowling Green, KY	Atlanta	401.4	Tolley et al.	No
Bristol, VA	Atlanta	401.4	Tolley et al.	No
Brunswick, GA	Atlanta	401.4	Tolley et al.	No
Charleston-North Charleston, SC	Atlanta	401.4	Tolley et al.	No
Charlotte-Gastonia-Concord, NC-SC	Atlanta	401.4	Tolley et al.	No
Chattanooga, TN-GA	Atlanta	401.4	Tolley et al.	No
Clarksville, TN-KY	Atlanta	401.4	Tolley et al.	No
Cleveland, TN	Atlanta	401.4	Tolley et al.	No
Columbia, SC	Atlanta	401.4	Tolley et al.	No
Columbus, GA-AL	Atlanta	401.4	Tolley et al.	No
Dalton, GA	Atlanta	401.4	Tolley et al.	No
Decatur, AL	Atlanta	401.4	Tolley et al.	No
Deltona-Daytona Beach-Ormond Beach, FL	Atlanta	401.4	Tolley et al.	No
Elizabethtown, KY	Atlanta	401.4	Tolley et al.	No
Florence, AL	Atlanta	401.4	Tolley et al.	No
Florence, SC	Atlanta	401.4	Tolley et al.	No
Gadsden, AL	Atlanta	401.4	Tolley et al.	No
Gainesville, FL	Atlanta	401.4	Tolley et al.	No
Gainesville, GA	Atlanta	401.4	Tolley et al.	No
Greenville, SC	Atlanta	401.4	Tolley et al.	No
Hickory-Morganton-Lenoir, NC	Atlanta	401.4	Tolley et al.	No
Hinesville-Fort Stewart, GA	Atlanta	401.4	Tolley et al.	No
Huntington-Ashland, WV-KY-OH	Atlanta	401.4	Tolley et al.	No
Huntsville, AL	Atlanta	401.4	Tolley et al.	No
Jackson, TN	Atlanta	401.4	Tolley et al.	No
Jacksonville, FL	Atlanta	401.4	Tolley et al.	No
Johnson City, TN	Atlanta	401.4	Tolley et al.	No
Kingsport-Bristol, TN-VA	Atlanta	401.4	Tolley et al.	No
Knoxville, TN	Atlanta	401.4	Tolley et al.	No
Lakeland-Winter Haven, FL	Atlanta	401.4	Tolley et al.	No
Lexington-Fayette, KY	Atlanta	401.4	Tolley et al.	No

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Macon, GA	Atlanta	401.4	Tolley et al.	No
Miami-Fort Lauderdale-Miami Beach, FL	Atlanta	401.4	Tolley et al.	No
Montgomery, AL	Atlanta	401.4	Tolley et al.	No
Morristown, TN	Atlanta	401.4	Tolley et al.	No
Naples-Marco Island, FL	Atlanta	401.4	Tolley et al.	No
Nashville-Davidson--Murfreesboro, TN	Atlanta	401.4	Tolley et al.	No
Ocala, FL	Atlanta	401.4	Tolley et al.	No
Orlando, FL	Atlanta	401.4	Tolley et al.	No
Palm Bay-Melbourne-Titusville, FL	Atlanta	401.4	Tolley et al.	No
Port St. Lucie-Fort Pierce, FL	Atlanta	401.4	Tolley et al.	No
Rome, GA	Atlanta	401.4	Tolley et al.	No
Sarasota-Bradenton-Venice, FL	Atlanta	401.4	Tolley et al.	No
Savannah, GA	Atlanta	401.4	Tolley et al.	No
Spartanburg, SC	Atlanta	401.4	Tolley et al.	No
Sumter, SC	Atlanta	401.4	Tolley et al.	No
Tallahassee, FL	Atlanta	401.4	Tolley et al.	No
Tampa-St. Petersburg-Clearwater, FL	Atlanta	401.4	Tolley et al.	No
Valdosta, GA	Atlanta	401.4	Tolley et al.	No
Vero Beach, FL	Atlanta	401.4	Tolley et al.	No
Warner Robins, GA	Atlanta	401.4	Tolley et al.	No
Albany-Schenectady-Troy, NY	Boston	490.54	Tolley et al.	Yes
Bangor, ME	Boston	490.54	Tolley et al.	Yes
Barnstable Town, MA	Boston	490.54	Tolley et al.	Yes
Boston-Cambridge-Quincy, MA-NH	Boston	490.54	Tolley et al.	Yes
Bridgeport-Stamford-Norwalk, CT	Boston	490.54	Tolley et al.	Yes
Burlington-South Burlington, VT	Boston	490.54	Tolley et al.	Yes
Glens Falls, NY	Boston	490.54	Tolley et al.	Yes
Hartford-West Hartford-East Hartford, CT	Boston	490.54	Tolley et al.	Yes
Kingston, NY	Boston	490.54	Tolley et al.	Yes
Lewiston-Auburn, ME	Boston	490.54	Tolley et al.	Yes
Manchester-Nashua, NH	Boston	490.54	Tolley et al.	Yes
New Haven-Milford, CT	Boston	490.54	Tolley et al.	Yes
New York-Newark-Edison, NY-NJ-PA	Boston	490.54	Tolley et al.	Yes
Norwich-New London, CT	Boston	490.54	Tolley et al.	Yes
Pittsfield, MA	Boston	490.54	Tolley et al.	Yes
Portland-South Portland, ME	Boston	490.54	Tolley et al.	Yes
Poughkeepsie-Newburgh-Middletown, NY	Boston	490.54	Tolley et al.	Yes
Providence-New Bedford-Fall River, RI-MA	Boston	490.54	Tolley et al.	Yes
Springfield, MA	Boston	490.54	Tolley et al.	Yes
Utica-Rome, NY	Boston	490.54	Tolley et al.	Yes
Worcester, MA	Boston	490.54	Tolley et al.	Yes
Ames, IA	Chicago	388.31	Tolley et al.	Yes
Anderson, IN	Chicago	388.31	Tolley et al.	Yes

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Ann Arbor, MI	Chicago	388.31	Tolley et al.	Yes
Appleton, WI	Chicago	388.31	Tolley et al.	Yes
Battle Creek, MI	Chicago	388.31	Tolley et al.	Yes
Bay City, MI	Chicago	388.31	Tolley et al.	Yes
Bloomington, IN	Chicago	388.31	Tolley et al.	Yes
Bloomington-Normal, IL	Chicago	388.31	Tolley et al.	Yes
Cedar Rapids, IA	Chicago	388.31	Tolley et al.	Yes
Champaign-Urbana, IL	Chicago	388.31	Tolley et al.	Yes
Chicago-Naperville-Joliet, IL-IN-WI	Chicago	388.31	Tolley et al.	Yes
Cincinnati-Middletown, OH-KY-IN	Chicago	388.31	Tolley et al.	Yes
Columbia, MO	Chicago	388.31	Tolley et al.	Yes
Columbus, IN	Chicago	388.31	Tolley et al.	Yes
Columbus, OH	Chicago	388.31	Tolley et al.	Yes
Danville, IL	Chicago	388.31	Tolley et al.	Yes
Davenport-Moline-Rock Island, IA-IL	Chicago	388.31	Tolley et al.	Yes
Dayton, OH	Chicago	388.31	Tolley et al.	Yes
Decatur, IL	Chicago	388.31	Tolley et al.	Yes
Des Moines, IA	Chicago	388.31	Tolley et al.	Yes
Detroit-Warren-Livonia, MI	Chicago	388.31	Tolley et al.	Yes
Dubuque, IA	Chicago	388.31	Tolley et al.	Yes
Duluth, MN-WI	Chicago	388.31	Tolley et al.	Yes
Eau Claire, WI	Chicago	388.31	Tolley et al.	Yes
Elkhart-Goshen, IN	Chicago	388.31	Tolley et al.	Yes
Evansville, IN-KY	Chicago	388.31	Tolley et al.	No
Fargo, ND-MN	Chicago	388.31	Tolley et al.	Yes
Flint, MI	Chicago	388.31	Tolley et al.	Yes
Fond du Lac, WI	Chicago	388.31	Tolley et al.	Yes
Fort Wayne, IN	Chicago	388.31	Tolley et al.	Yes
Grand Forks, ND-MN	Chicago	388.31	Tolley et al.	Yes
Grand Rapids-Wyoming, MI	Chicago	388.31	Tolley et al.	Yes
Green Bay, WI	Chicago	388.31	Tolley et al.	Yes
Holland-Grand Haven, MI	Chicago	388.31	Tolley et al.	Yes
Indianapolis, IN	Chicago	388.31	Tolley et al.	Yes
Iowa City, IA	Chicago	388.31	Tolley et al.	Yes
Jackson, MI	Chicago	388.31	Tolley et al.	Yes
Janesville, WI	Chicago	388.31	Tolley et al.	Yes
Jefferson City, MO	Chicago	388.31	Tolley et al.	Yes
Joplin, MO	Chicago	388.31	Tolley et al.	Yes
Kalamazoo-Portage, MI	Chicago	388.31	Tolley et al.	Yes
Kankakee-Bradley, IL	Chicago	388.31	Tolley et al.	Yes
Kansas City, MO-KS	Chicago	388.31	Tolley et al.	Yes
Kokomo, IN	Chicago	388.31	Tolley et al.	Yes
La Crosse, WI-MN	Chicago	388.31	Tolley et al.	Yes

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Lafayette, IN	Chicago	388.31	Tolley et al.	Yes
Lansing-East Lansing, MI	Chicago	388.31	Tolley et al.	Yes
Lawrence, KS	Chicago	388.31	Tolley et al.	Yes
Lima, OH	Chicago	388.31	Tolley et al.	Yes
Louisville, KY-IN	Chicago	388.31	Tolley et al.	No
Madison, WI	Chicago	388.31	Tolley et al.	Yes
Michigan City-La Porte, IN	Chicago	388.31	Tolley et al.	Yes
Milwaukee-Waukesha-West Allis, WI	Chicago	388.31	Tolley et al.	Yes
Minneapolis-St. Paul-Bloomington, MN-WI	Chicago	388.31	Tolley et al.	Yes
Monroe, MI	Chicago	388.31	Tolley et al.	Yes
Muncie, IN	Chicago	388.31	Tolley et al.	Yes
Muskegon-Norton Shores, MI	Chicago	388.31	Tolley et al.	Yes
Niles-Benton Harbor, MI	Chicago	388.31	Tolley et al.	Yes
Omaha-Council Bluffs, NE-IA	Chicago	388.31	Tolley et al.	Yes
Oshkosh-Neenah, WI	Chicago	388.31	Tolley et al.	Yes
Owensboro, KY	Chicago	388.31	Tolley et al.	No
Peoria, IL	Chicago	388.31	Tolley et al.	Yes
Racine, WI	Chicago	388.31	Tolley et al.	Yes
Rochester, MN	Chicago	388.31	Tolley et al.	Yes
Rockford, IL	Chicago	388.31	Tolley et al.	Yes
Saginaw-Saginaw Township North, MI	Chicago	388.31	Tolley et al.	Yes
Sandusky, OH	Chicago	388.31	Tolley et al.	Yes
Sheboygan, WI	Chicago	388.31	Tolley et al.	Yes
Sioux City, IA-NE-SD	Chicago	388.31	Tolley et al.	Yes
South Bend-Mishawaka, IN-MI	Chicago	388.31	Tolley et al.	Yes
Springfield, IL	Chicago	388.31	Tolley et al.	Yes
Springfield, MO	Chicago	388.31	Tolley et al.	Yes
Springfield, OH	Chicago	388.31	Tolley et al.	Yes
St. Cloud, MN	Chicago	388.31	Tolley et al.	Yes
St. Joseph, MO-KS	Chicago	388.31	Tolley et al.	Yes
St. Louis, MO-IL	Chicago	388.31	Tolley et al.	Yes
Terre Haute, IN	Chicago	388.31	Tolley et al.	Yes
Toledo, OH	Chicago	388.31	Tolley et al.	Yes
Topeka, KS	Chicago	388.31	Tolley et al.	Yes
Waterloo-Cedar Falls, IA	Chicago	388.31	Tolley et al.	Yes
Wausau, WI	Chicago	388.31	Tolley et al.	Yes
Abilene, TX	Denver	902.9	Tolley et al.	Yes
Albuquerque, NM	Denver	902.9	Tolley et al.	No
Amarillo, TX	Denver	902.9	Tolley et al.	Yes
Billings, MT	Denver	902.9	Tolley et al.	Yes
Bismarck, ND	Denver	902.9	Tolley et al.	Yes
Boulder, CO	Denver	902.9	Tolley et al.	No
Casper, WY	Denver	902.9	Tolley et al.	Yes

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Cheyenne, WY	Denver	902.9	Tolley et al.	Yes
Colorado Springs, CO	Denver	902.9	Tolley et al.	No
Denver-Aurora, CO	Denver	902.9	Tolley et al.	No
El Paso, TX	Denver	902.9	Tolley et al.	Yes
Farmington, NM	Denver	902.9	Tolley et al.	No
Fort Collins-Loveland, CO	Denver	902.9	Tolley et al.	No
Grand Junction, CO	Denver	902.9	Tolley et al.	No
Great Falls, MT	Denver	902.9	Tolley et al.	Yes
Greeley, CO	Denver	902.9	Tolley et al.	No
Idaho Falls, ID	Denver	902.9	Tolley et al.	Yes
Las Cruces, NM	Denver	902.9	Tolley et al.	No
Lawton, OK	Denver	902.9	Tolley et al.	Yes
Lincoln, NE	Denver	902.9	Tolley et al.	Yes
Logan, UT-ID	Denver	902.9	Tolley et al.	No
Lubbock, TX	Denver	902.9	Tolley et al.	Yes
Midland, TX	Denver	902.9	Tolley et al.	Yes
Missoula, MT	Denver	902.9	Tolley et al.	Yes
Odessa, TX	Denver	902.9	Tolley et al.	Yes
Ogden-Clearfield, UT	Denver	902.9	Tolley et al.	No
Oklahoma City, OK	Denver	902.9	Tolley et al.	Yes
Pocatello, ID	Denver	902.9	Tolley et al.	Yes
Provo-Orem, UT	Denver	902.9	Tolley et al.	No
Pueblo, CO	Denver	902.9	Tolley et al.	No
Rapid City, SD	Denver	902.9	Tolley et al.	Yes
Salt Lake City, UT	Denver	902.9	Tolley et al.	No
San Angelo, TX	Denver	902.9	Tolley et al.	Yes
Santa Fe, NM	Denver	902.9	Tolley et al.	No
Sioux Falls, SD	Denver	902.9	Tolley et al.	Yes
Tulsa, OK	Denver	902.9	Tolley et al.	Yes
Wichita Falls, TX	Denver	902.9	Tolley et al.	Yes
Wichita, KS	Denver	902.9	Tolley et al.	Yes
Bakersfield, CA	Los Angeles	117.69	Brookshire et al.	No
Bellingham, WA	Los Angeles	117.69	Brookshire et al.	Yes
Bend, OR	Los Angeles	117.69	Brookshire et al.	Yes
Boise City-Nampa, ID	Los Angeles	117.69	Brookshire et al.	Yes
Bremerton-Silverdale, WA	Los Angeles	117.69	Brookshire et al.	Yes
Carson City, NV	Los Angeles	117.69	Brookshire et al.	No
Chico, CA	Los Angeles	117.69	Brookshire et al.	No
Coeur d'Alene, ID	Los Angeles	117.69	Brookshire et al.	Yes
Corvallis, OR	Los Angeles	117.69	Brookshire et al.	Yes
El Centro, CA	Los Angeles	117.69	Brookshire et al.	No
Eugene-Springfield, OR	Los Angeles	117.69	Brookshire et al.	Yes
Flagstaff, AZ	Los Angeles	117.69	Brookshire et al.	No

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Fresno, CA	Los Angeles	117.69	Brookshire et al.	No
Hanford-Corcoran, CA	Los Angeles	117.69	Brookshire et al.	No
Kennewick-Richland-Pasco, WA	Los Angeles	117.69	Brookshire et al.	Yes
Las Vegas-Paradise, NV	Los Angeles	117.69	Brookshire et al.	No
Lewiston, ID-WA	Los Angeles	117.69	Brookshire et al.	Yes
Longview-Kelso, WA	Los Angeles	117.69	Brookshire et al.	Yes
Los Angeles-Long Beach-Santa Ana, CA	Los Angeles	117.69	Brookshire et al.	No
Madera, CA	Los Angeles	117.69	Brookshire et al.	No
Medford, OR	Los Angeles	117.69	Brookshire et al.	Yes
Merced, CA	Los Angeles	117.69	Brookshire et al.	No
Modesto, CA	Los Angeles	117.69	Brookshire et al.	No
Mount Vernon-Anacortes, WA	Los Angeles	117.69	Brookshire et al.	Yes
Olympia, WA	Los Angeles	117.69	Brookshire et al.	Yes
Oxnard-Thousand Oaks-Ventura, CA	Los Angeles	117.69	Brookshire et al.	No
Phoenix-Mesa-Scottsdale, AZ	Los Angeles	117.69	Brookshire et al.	No
Portland-Vancouver-Beaverton, OR-WA	Los Angeles	117.69	Brookshire et al.	Yes
Prescott, AZ	Los Angeles	117.69	Brookshire et al.	No
Redding, CA	Los Angeles	117.69	Brookshire et al.	No
Reno-Sparks, NV	Los Angeles	117.69	Brookshire et al.	No
Riverside-San Bernardino-Ontario, CA	Los Angeles	117.69	Brookshire et al.	No
Sacramento--Arden-Arcade--Roseville, CA	Los Angeles	117.69	Brookshire et al.	No
Salem, OR	Los Angeles	117.69	Brookshire et al.	Yes
Salinas, CA	Los Angeles	117.69	Brookshire et al.	No
San Diego-Carlsbad-San Marcos, CA	Los Angeles	117.69	Brookshire et al.	No
San Luis Obispo-Paso Robles, CA	Los Angeles	117.69	Brookshire et al.	No
Santa Barbara-Santa Maria-Goleta, CA	Los Angeles	117.69	Brookshire et al.	No
Seattle-Tacoma-Bellevue, WA	Los Angeles	117.69	Brookshire et al.	Yes
Spokane, WA	Los Angeles	117.69	Brookshire et al.	Yes
St. George, UT	Los Angeles	117.69	Brookshire et al.	No
Stockton, CA	Los Angeles	117.69	Brookshire et al.	No
Tucson, AZ	Los Angeles	117.69	Brookshire et al.	No
Visalia-Porterville, CA	Los Angeles	117.69	Brookshire et al.	No
Wenatchee, WA	Los Angeles	117.69	Brookshire et al.	Yes
Yakima, WA	Los Angeles	117.69	Brookshire et al.	Yes
Yuba City-Marysville, CA	Los Angeles	117.69	Brookshire et al.	No
Yuma, AZ	Los Angeles	117.69	Brookshire et al.	No
Alexandria, LA	Mobile	385.75	Tolley et al.	Yes
Austin-Round Rock, TX	Mobile	385.75	Tolley et al.	Yes
Baton Rouge, LA	Mobile	385.75	Tolley et al.	Yes
Beaumont-Port Arthur, TX	Mobile	385.75	Tolley et al.	Yes
Brownsville-Harlingen, TX	Mobile	385.75	Tolley et al.	Yes
Cape Coral-Fort Myers, FL	Mobile	385.75	Tolley et al.	No
College Station-Bryan, TX	Mobile	385.75	Tolley et al.	Yes

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Corpus Christi, TX	Mobile	385.75	Tolley et al.	Yes
Dallas-Fort Worth-Arlington, TX	Mobile	385.75	Tolley et al.	Yes
Dothan, AL	Mobile	385.75	Tolley et al.	No
Fayetteville-Springdale-Rogers, AR-MO	Mobile	385.75	Tolley et al.	Yes
Fort Smith, AR-OK	Mobile	385.75	Tolley et al.	Yes
Fort Walton Beach-Crestview-Destin, FL	Mobile	385.75	Tolley et al.	No
Gulfport-Biloxi, MS	Mobile	385.75	Tolley et al.	No
Hattiesburg, MS	Mobile	385.75	Tolley et al.	No
Hot Springs, AR	Mobile	385.75	Tolley et al.	Yes
Houma-Bayou Cane-Thibodaux, LA	Mobile	385.75	Tolley et al.	Yes
Houston-Baytown-Sugar Land, TX	Mobile	385.75	Tolley et al.	Yes
Jackson, MS	Mobile	385.75	Tolley et al.	No
Jonesboro, AR	Mobile	385.75	Tolley et al.	Yes
Killeen-Temple-Fort Hood, TX	Mobile	385.75	Tolley et al.	Yes
Lafayette, LA	Mobile	385.75	Tolley et al.	Yes
Lake Charles, LA	Mobile	385.75	Tolley et al.	Yes
Laredo, TX	Mobile	385.75	Tolley et al.	Yes
Little Rock-North Little Rock, AR	Mobile	385.75	Tolley et al.	Yes
Longview, TX	Mobile	385.75	Tolley et al.	Yes
McAllen-Edinburg-Pharr, TX	Mobile	385.75	Tolley et al.	Yes
Memphis, TN-MS-AR	Mobile	385.75	Tolley et al.	No
Mobile, AL	Mobile	385.75	Tolley et al.	No
Monroe, LA	Mobile	385.75	Tolley et al.	Yes
New Orleans-Metairie-Kenner, LA	Mobile	385.75	Tolley et al.	Yes
Panama City-Lynn Haven, FL	Mobile	385.75	Tolley et al.	No
Pascagoula, MS	Mobile	385.75	Tolley et al.	No
Pensacola-Ferry Pass-Brent, FL	Mobile	385.75	Tolley et al.	No
Pine Bluff, AR	Mobile	385.75	Tolley et al.	Yes
Punta Gorda, FL	Mobile	385.75	Tolley et al.	No
San Antonio, TX	Mobile	385.75	Tolley et al.	Yes
Sherman-Denison, TX	Mobile	385.75	Tolley et al.	Yes
Shreveport-Bossier City, LA	Mobile	385.75	Tolley et al.	Yes
Texarkana, TX-Texarkana, AR	Mobile	385.75	Tolley et al.	Yes
Tuscaloosa, AL	Mobile	385.75	Tolley et al.	No
Tyler, TX	Mobile	385.75	Tolley et al.	Yes
Victoria, TX	Mobile	385.75	Tolley et al.	Yes
Waco, TX	Mobile	385.75	Tolley et al.	Yes
Napa, CA	San Francisco	1225.49	Loehman et al.	No
San Francisco-Oakland-Fremont, CA	San Francisco	1225.49	Loehman et al.	No
San Jose-Sunnyvale-Santa Clara, CA	San Francisco	1225.49	Loehman et al.	No
Santa Cruz-Watsonville, CA	San Francisco	1225.49	Loehman et al.	No
Santa Rosa-Petaluma, CA	San Francisco	1225.49	Loehman et al.	No
Vallejo-Fairfield, CA	San Francisco	1225.49	Loehman et al.	No

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Akron, OH	Washington DC	756.86	Tolley et al.	Yes
Allentown-Bethlehem-Easton, PA-NJ	Washington DC	756.86	Tolley et al.	Yes
Altoona, PA	Washington DC	756.86	Tolley et al.	Yes
Atlantic City, NJ	Washington DC	756.86	Tolley et al.	Yes
Baltimore-Towson, MD	Washington DC	756.86	Tolley et al.	No
Binghamton, NY	Washington DC	756.86	Tolley et al.	Yes
Blacksburg-Christiansburg-Radford, VA	Washington DC	756.86	Tolley et al.	No
Buffalo-Cheektowaga-Tonawanda, NY	Washington DC	756.86	Tolley et al.	Yes
Burlington, NC	Washington DC	756.86	Tolley et al.	No
Canton-Massillon, OH	Washington DC	756.86	Tolley et al.	Yes
Charleston, WV	Washington DC	756.86	Tolley et al.	No
Charlottesville, VA	Washington DC	756.86	Tolley et al.	No
Cleveland-Elyria-Mentor, OH	Washington DC	756.86	Tolley et al.	Yes
Cumberland, MD-WV	Washington DC	756.86	Tolley et al.	No
Danville, VA	Washington DC	756.86	Tolley et al.	No
Dover, DE	Washington DC	756.86	Tolley et al.	No
Durham, NC	Washington DC	756.86	Tolley et al.	No
Elmira, NY	Washington DC	756.86	Tolley et al.	Yes
Erie, PA	Washington DC	756.86	Tolley et al.	Yes
Fayetteville, NC	Washington DC	756.86	Tolley et al.	No
Goldsboro, NC	Washington DC	756.86	Tolley et al.	No
Greensboro-High Point, NC	Washington DC	756.86	Tolley et al.	No
Greenville, NC	Washington DC	756.86	Tolley et al.	No
Hagerstown-Martinsburg, MD-WV	Washington DC	756.86	Tolley et al.	No
Harrisburg-Carlisle, PA	Washington DC	756.86	Tolley et al.	Yes
Harrisonburg, VA	Washington DC	756.86	Tolley et al.	No
Ithaca, NY	Washington DC	756.86	Tolley et al.	Yes
Jacksonville, NC	Washington DC	756.86	Tolley et al.	No
Johnstown, PA	Washington DC	756.86	Tolley et al.	Yes
Lancaster, PA	Washington DC	756.86	Tolley et al.	Yes
Lebanon, PA	Washington DC	756.86	Tolley et al.	Yes
Lynchburg, VA	Washington DC	756.86	Tolley et al.	No
Mansfield, OH	Washington DC	756.86	Tolley et al.	Yes
Morgantown, WV	Washington DC	756.86	Tolley et al.	No
Myrtle Beach-Conway-North Myrtle Beach, SC	Washington DC	756.86	Tolley et al.	No
Ocean City, NJ	Washington DC	756.86	Tolley et al.	Yes
Parkersburg-Marietta, WV-OH	Washington DC	756.86	Tolley et al.	No
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	Washington DC	756.86	Tolley et al.	Yes
Pittsburgh, PA	Washington DC	756.86	Tolley et al.	Yes
Raleigh-Cary, NC	Washington DC	756.86	Tolley et al.	No
Reading, PA	Washington DC	756.86	Tolley et al.	Yes
Richmond, VA	Washington DC	756.86	Tolley et al.	No
Roanoke, VA	Washington DC	756.86	Tolley et al.	No

MSA Name	Nearest Study City	*b* Value	Citation	Included in Scenario 2
Rochester, NY	Washington DC	756.86	Tolley et al.	Yes
Rocky Mount, NC	Washington DC	756.86	Tolley et al.	No
Salisbury, MD	Washington DC	756.86	Tolley et al.	No
Scranton--Wilkes-Barre, PA	Washington DC	756.86	Tolley et al.	Yes
State College, PA	Washington DC	756.86	Tolley et al.	Yes
Syracuse, NY	Washington DC	756.86	Tolley et al.	Yes
Trenton-Ewing, NJ	Washington DC	756.86	Tolley et al.	Yes
Vineland-Millville-Bridgeton, NJ	Washington DC	756.86	Tolley et al.	Yes
Virginia Beach-Norfolk-Newport News, VA-NC	Washington DC	756.86	Tolley et al.	No
Washington-Arlington-Alexandria, DC-VA-MD-WV	Washington DC	756.86	Tolley et al.	No
Weirton-Steubenville, WV-OH	Washington DC	756.86	Tolley et al.	No
Wheeling, WV-OH	Washington DC	756.86	Tolley et al.	No
Williamsport, PA	Washington DC	756.86	Tolley et al.	Yes
Wilmington, NC	Washington DC	756.86	Tolley et al.	No
Winchester, VA-WV	Washington DC	756.86	Tolley et al.	No
Winston-Salem, NC	Washington DC	756.86	Tolley et al.	No
York-Hanover, PA	Washington DC	756.86	Tolley et al.	No
Youngstown-Warren-Boardman, OH-PA	Washington DC	756.86	Tolley et al.	Yes