MEMORANDUM

June 3, 1999

TO: Jim DeMocker, EPA

FROM: Naomi Kleckner and Jim Neumann, IEc

SUBJECT: Recommended Approach to Adjusting WTP Estimates to Reflect Changes in Real Income

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As part of the on-going effort to refine the economic valuation methodology of the 812 prospective analyses, IEc and the Agency have proposed adjusting willingness-to-pay (WTP) measures to reflect the expected increase in real income over the period, 1990 to 2010. This approach would result in an upward adjustment to more accurately reflect the valuation of improved health as income increases over time. However, application of this adjustment to benefits estimation requires extensive incorporation of new literature to ensure that applied estimates reflect sound methodology consistent with those of the 812 prospective.

This memorandum presents our recommended approach for implementing an income-growth adjustment. The first section addresses economic issues associated with estimating income elasticity and expectations of whether improvements in health status are luxury or necessity goods. The second section, Estimates of Income Elasticity of WTP, reviews studies that present income elasticity estimates and discusses their strengths and weaknesses. The final section presents our recommendations for incorporating the results of this review in the 812 prospective analysis and some illustrative examples of the potential effects of this adjustment on benefit estimates. We then conclude the memorandum with comments on critical uncertainties affecting the interpretation of the results.

BACKGROUND

There is some intuitive appeal to the general impression that environmental improvements are luxury goods. McFadden and Leonard (1992) write, "Environmental protection should be a 'luxury good' that in poor families is displaced by basic needs for food and shelter, and in wealthy families more affordable" (sic). Intuition is further supported by the "inverted U-shaped" relationship observed between income and industrial pollution. This relationship, often called the "environmental Kuznet's curve," traces a pattern where low levels of income are often correlated with little industrial pollution. As income increases, so does the level of pollution. This relationship eventually changes, and pollution levels decrease with higher income levels.

Two recent articles explain why the general perception of environmental improvement as a luxury good is potentially incorrect and a direct result of assessing the income effect on public goods as if they were private goods. Kriström and Riera (1996) review empirical evidence from European studies indicating income elasticity of environmental improvement is positive, but considerably less than one (i.e., environmental improvement is a necessity good). Their findings suggest that as income increases, an individual will want to consume more of a given good. This finding, however, does not necessarily imply that the person is willing to pay more for each unit.[1] Flores and Carson (1997) place emphasis on the how individuals allocate income among private and public goods. They discuss the implications of incorrectly defining goods as private or public, and the accompanying interpretation of income elasticity estimates, as central to resource allocation. Assuming an income elasticity of environmental protection greater than one may imply that environmental protection disproportionately favors the wealthy at the expense of lower income groups (Flores and Carson, 1997).

Income Elasticity of Demand Versus Income Elasticity of Willingness to Pay

Economist use income elasticity to evaluate the how private and public goods are valued based on the interaction between income changes and demand. A negative relationship between income and demand for a good implies that the good is an inferior good. An individual demands less of a good as income rises. A positive relationship between income and the demand for a good implies that the good is normal (i.e., income elasticity is greater than zero). As income rises an individual demands more of a good. Depending on the relative responsiveness of demand to income changes, normal goods are characterized as a necessity or a luxury. When income elasticity is between 0 and +1, the good is considered a *necessity* (i.e., demand is not significantly responsive

[1]Kriström and Riera (1996) examine empirical evidence that suggests income elasticity of WTP ranges between 0.20 and 0.30 rather than being closer to one.

to income). In contrast, when income elasticity exceeds +1, the good is considered a *luxury* (i.e., the relative increase in the good's demand exceeds the increase in income).

The determination of a public good as inferior or normal based on income elasticity is complicated by its nonrival nature.[2] In the case of a private good, varying the level of consumption is measured as a marginal change and implies that an individual will adjust his or her consumption level of other good(s). Consequently, income elasticity of demand estimates changes in quantity consumed, and not necessarily changes in utility (or the individual's well-being). With public goods, this is not true. Income elasticity of WTP for public goods measures changes in consumer surplus. For example, one person enjoying the benefits of cleaner air is does not reduce the probability of another person enjoying the same benefits. There are no apparent mechanisms for regulating who specifically will enjoy the benefits. In other words, there is no direct relationship between an individual's WTP and level of consumption.[3] The consumption level of public goods is exogenous to the individual's budget constraint. At the same time, WTP for a public good is not. An individual, therefore, must consider how his or her WTP affects the allocation of income among private and public goods.[4]

Flores and Carson (1997) provide examples of how income elasticity can change depending on how the good is defined (i.e., private or public). Given the divergence between private and public goods, they conclude that income elasticity of WTP and income elasticity of demand are related. The relationship does not imply that knowledge of income elasticity of demand is sufficient to estimate income elasticity of WTP given that the income elasticity of WTP depends on factors that cannot be observed.

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[2]Public goods by definition must be nonrival and generally are nonexclusive.

[3]The nonrival nature of public goods implies that the marginal social cost of consuming an additional unit of benefit is zero.

[4]CV studies solicit WTP estimates that are subject to the respondent's current budget constraint. The budget share factor requires that the income elasticities (for all consumed goods) sum to one. This generally implies that income elasticity of any single good is substantially less than one.

ESTIMATES OF INCOME ELASTICITY OF WTP FOR MORBIDITY AND MORTALITY REDUCTIONS

Income Elasticity of WTP to Avoid Adverse Health Effects

There are several different approaches to the valuation of morbidity endpoints. The most commonly cited are contingent valuation (CV) studies and cost of illness (COI) studies. CV studies are the primary source from which estimates of income elasticity of willingness to pay are derived.[5] We also reviewed elasticities based on the demand for health care. The health care studies characterize the demand for health care by generating estimates of the WTP to avoid a marginal decline in general health. Like CV studies, the demand for health care studies have a foundation in utility theory, and the solicited bids are subject to a budget constraint. It is important to note that there are a few distinguishing characteristics between these two sources of elasticity estimates. Despite the fact that the symptoms are attributed to environmental pollution, the surveyed individuals in CV studies are generally presented with scenarios that guarantee the elimination of a symptom. Like many CV studies, the health care studies incorporate uncertainty with respect to improved health status. In other words, the health care studies derive estimates of WTP to reduce the probability of a decline in health status.

CV studies solicit *ex ante* estimates of WTP to avoid an adverse health effect based on a description of an illness' symptoms and severity. The health effects found in WTP studies can be loosely separated into two groups, minor and severe morbidity endpoints.[6] Minor health effects include symptoms with short durations. In addition, this category includes estimates of the income elasticity of health care, because they exhibit a similar pattern of the diminishing marginal utility as investment increases and solicit estimates that reflect small changes in health status. The category "severe health effects" is comprised of symptoms with longer durations, considered chronic, and to some extent conditions labeled acute. Also included are income elasticity estimates for "general good health" and avoidance of health effects with significant costs.

Exhibit 1 summarizes the estimates of income elasticity of WTP to avoid morbidity health effects. The range of income elasticity estimates indicate that the benefits of avoiding morbidity effects are valued as necessity goods (i.e., income elasticity is between zero and one). Estimates are between 0.04 and 0.60. Separating the effects into minor and severe categories narrows the variation in values. Income elasticity of WTP for avoiding a minor health effects range between 0.04 and 0.30. As expected, the relationship between income and more severe health effects is considerably

[5]It may be possible to adjust COI estimates as well, through more straightforward estimates of the future cost of medical treatment, but we have not researched the availability of such estimates or evaluated their reliability.

[6]For example, the distinction between respiratory conditions, such as asthma and chronic bronchitis, are described by duration (e.g., one day versus 240 days) and symptom (e.g, severe shortness of breath versus severe cough).

stronger, but still fairly inelastic. For severe health effects estimates range between 0.25 and 0.60. We provide a more detailed table of estimates and their sources in Attachment A.

Exhibit 1
INCOME ELASTICITY OF WTP TO AVOID MORBIDITY EFFECTS

Valuation Study	Income Elasticity of WTP	
	Minor Health Effect Estimate	Severe Health Effect Estimate
Alberini *et al.* (1997)	-	0.45
Loehman *et al.* (1979)	0.26	0.60
Rowe and Chestnut (1985)	0.06	0.51
Viscusi and Evans (1993)	0.17	0.38
Holtman and Olsen (1978)[1]	0.06 - 0.30	-
Manning *et al.* (1981)[1]	0.04	-
Persson *et al.* (1995)	-	0.25 - 0.37
Phelps (1975)[1]	0.11	-
Mean Value[2]	**0.14**	**0.45**
Median Value	**0.14**	**0.45**

Notes:
1 These estimates reflect the income elasticity of demand for health care.
2. Mean value is based on averaging the central estimates from each study.

Income Elasticity of WTP to Reduce the Risk of Mortality

Much of the literature assumes that the income elasticity of the willingness to pay for reduced risk of mortality is at least equal to one. This implies that as income rises, the "value of life" increases (at least) at the same rate. Blomquist (1979) identifies the foregone earning approach as a likely source of this belief. Contrary to this assumption, empirical evidence indicates that estimates of income elasticity of VSL are considerably less than one; values tend to be concentrated around 0.30. In other words, while income and VSL estimates are positively correlated, the value of life is not very responsive to changes in income.

Exhibit 2 summarizes estimates of income elasticity of WTP to avoid death from seven primary studies. Three of the seven studies, Mitchell and Carson (1986), Blomquist (1979), and Viscusi and Evans (1993), are U.S-based. The first two studies report similar results, income elasticity estimates of 0.30 and 0.35. Mitchell and Carson provide an estimate based on a CV study of drinking water. They estimate income elasticity is .035. Blomquist (1979) generates an estimate in the same range. His estimate is based on 1972 consumption-activity data regarding seatbelt use

to reduce the risk of fatal injuries. In support of his results, Blomquist writes, "Although the connection between the expected present value of future labor earnings and consumption is not direct, the finding that the elasticity of value of life with respect to earnings is about 0.3 is consistent with the notion that people get more from life than what they derive from market consumption." Viscusi and Evans (1993) is a wage-risk study specifically examining the relationship between utility functions and health status. Their income elasticity estimates, 0.67 and 1.10, are considerably higher than other studies. This study is the only one with an elasticity estimate approximately equal to one.[7]

The remaining four studies are European based. The majority derive VSL estimates based on the valuation of reduced risk of automobile-related fatality. Johannesson and Johansson (1997) is the only European study that generates a VSL estimate not associated with traffic safety and attempt to measure the value adult Swedes place on an increased survival probability at advanced ages. Using an insurance premium scenario, the authors calculate a person's willingness to pay for a program increasing the expected length of life by one year (given the person survives to the age of 75). Analysis yields income elasticity of WTP values between 0.22 and 0.25 (for the standard and conservative estimations of WTP, respectively).[8]

In addition to presenting results from primary work, Exhibit 2 includes ranges suggested by two other reports that reviewed literature on this topic. Both NERA (1998) and Krupnick *et al.* (1995) cite elasticity ranges consistent with our analysis. The reports recommend a central income elasticity estimate of approximately 0.30 and high estimate of unit elasticity. NERA writes, "From a purely theoretical point of view, there are grounds for believing that for any particular context, the elasticity of the WTP-based value-of-statistical-life (VOSL) with respect to income or wealth will tend to be greater than unity." (NERA/CASPAR, 1998.) Both NERA and Krupnick *et al.* also acknowledge that there is little empirical evidence to support an income elasticity estimate of one.

We provide a more detailed summary of the estimate of income elasticity of VSL in Attachment B.

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[7] They use two different utility models (i.e., Taylor series and logarithmic) to generate estimates. The authors note that the logarithmic utility function, from which the 1.10 estimate is derived, is more frequently used in a finance context.

[8] It is important to note that there are several shortcomings with the study, which may account for the low estimate of income elasticity. Most obvious is the significant discounting of benefits that occur in the future due to the survey population ages (i.e., ages are between 18 and 69).

Exhibit 2
INCOME ELASTICITY OF WTP TO REDUCE THE RISK OF MORTALITY

Valuation Study	Income Elasticity of VSL	
	Low Estimate	**High Estimate**
Blomquist (1979)	0.3	0.3
Johannesson and Johansson (1997)	0.22	0.25
Jones-Lee *et al.* (1985)	0.30	0.40
Miller and Guria (1991)	0.08	0.29
Mitchell and Carson (1986)	0.35	0.35
Persson *et al.* (1995)	0.46	0.46
Viscusi and Evans (1990)	0.67	1.1
Krupnick et al. (1995) [1]	0.35	1
NERA/CASPAR (1998) [2]	0.30	1.1
Mean Value	**0.34**	**0.45**
Median Value	**0.30**	**0.35**

Notes:
1 Krupnick at al. base the low estimate on a study by Mitchell and Carson (1986). The authors do not cite a study for the high estimate and write, "With very limited data, one can assume that WTP for damage avoidance is proportional to income." To avoid double counting, these values are excluded from the mean and median calculations.
2 The authors base the low estimate on a review of several studies. The high estimate reflects two studies, Viscusi and Evans (1990) and Kidholm (1995). To avoid double counting, these values are excluded from the mean and median calculations.

Cross-Sectional Data vs. Longitudinal

It is important to keep in mind that we are interested in how WTP changes with respect to increases in U.S. median income. Measuring changes due to growth in median income reflect shifts in *overall* preferences and utility (or in the case of public goods, social welfare). This type of analysis requires time series data. Unfortunately, there are very few relevant studies that use this approach to estimate income elasticity.[9] Consequently, this memo reviews income elasticities estimated from cross-sectional data. The estimates reflect differences in willingness to pay for improved health among various income levels. They are measures of an individual's preferences and expected utility given the person's *current* state (i.e., in the present).

There are several issues associated with the application of cross-sectional results to estimate longitudinal changes (i.e., changes over time). Most important is the potential for misinterpretation of our recommended application of income elasticity adjustment. Although we outline an approach that uses income elasticities derived from cross-sectional data, the adjustment is solely a proxy for how preferences and utility may change as projected *overall* average income (i.e., real GDP per capita) increases from 1990 to 2010. Application of these income elasticity estimates does not imply a strategy for adjusting benefits valuation by level of household income in any given year.

RECOMMENDATION

In response to EPA's presentations to the Science Advisory Board (SAB) during the February 1998 consultation, SAB members indicated support for the conceptual basis of adjusting WTP estimates to account for changes in real income over time. The Council also expressed uncertainty about the empirical basis for such an adjustment given the scarcity of reliable and appropriate estimates of income elasticities over time.

Based on our review of the available income elasticity literature, we propose conducting sensitivity analyses that characterize how the valuation of human health benefits may increase with a rise in real U.S. income. Given some of the different methodological approaches and limited available research, we suggest separate upper and lower bounds for characterizing the uncertainty associated with an income effect on the valuation of morbidity and mortality effects. Exhibit 3 summarizes recommended income elasticities values for conducting a sensitivity analysis.

[9]Available studies using time series data estimate income elasticity of public health care expenditures by analyzing changes in government spending relative to gross domestic product (GDP). These studies are not particularly applicable to the 812 valuation methodology.

Exhibit 3

RECOMMENDED VALUES FOR CONDUCTING SENSITIVITY ANALYSIS OF INCOME EFFECT

Health Endpoint	Lower Bound	Central Estimate	Upper Bound
Minor Health Effect	0.04	0.14	0.30
Severe and Chronic Health Effects	0.25	0.45	0.60
Premature Mortality	0.08	0.40	1.00

Note: These ranges reflect values reported in Exhibit 1 and 2.

Reported income elasticities suggest that the severity of the morbidity endpoint is a primary determinant of the strength of the relationship between changes in income and the willingness to pay. Without accounting for severity, there is a fairly wide range of values for income elasticity, 0.04 to 0.60. Estimates are more closely clustered if we account for the seriousness of the health effect. For the purposes of a sensitivity analysis, we suggest using two different ranges based on whether morbidity endpoint are minor or severe. With respect to minor health effects, we suggest lower and upper bounds of 0.04 and 0.30, respectively. The central estimate is 0.14. For conducting a sensitivity test of the income elasticity effect on WTP to avoid severe health effects, we recommend a lower and upper bound of 0.25 and 0.60, with 0.45 as the central estimate. The lower and upper bounds reflect the lowest and highest estimates presented in Exhibit 1. The central estimate is the midpoint of the averages from each study.

With respect to VSL, estimates of income elasticity range from 0.08 to 1.10. We recommend using lower and upper bounds that reflect the full range of values. The central estimate, 0.40, represents the midpoint between the average low value and the average high value of the studies presented in Exhibit 2.

Illustrative Example of Income Elasticity Effect on Morbidity Benefits Estimates

Exhibit 4 provides a simplified example of how the suggested ranges could affect benefits estimates. For illustrative purposes, we use the WTP to avoid an asthma attack to represent a minor health effect and WTP to avoid a case of chronic bronchitis to represent a severe health effect. By the year 2010, the effect of income growth on WTP for a minor health effect can increase between one and eight percent, with the central estimate indicating three percent growth. The WTP to avoid a severe health effect grows faster with 2010 estimates, ranging between seven and sixteen percent and with the central estimate increasing by thirteen percent.

Exhibit 4 ILLUSTRATIVE ADJUSTMENT TO ESTIMATES OF WTP TO AVOID MORBIDITY (1990 Dollars)						
Year	**US Population**	**Real GDP**	**Income**	**WTP Estimate[1]**		
				Lower Bound	**Central Estimate**	**Upper Bound**
Minor Health Effect*- *Asthma				**E_y=0.04**	**E_y=0.14**	**E_y=0.30**
1990	249,440	6,136,300,000	24.60	$38	$38	$38
2000	274,634	7,609,900,000	27.71	$38.18	$38.64	$39.38
2010	297,716	9,571,580,000	32.15	$38.41	$39.45	$41.18
Severe Health Effect- Chronic Bronchitis				**E_y=0.25**	**E_y=0.45**	**E_y=0.60**
1990	249,440	6,136,300,000	24.60	$306,000	$306,000	$306,000
2000	274,634	7,609,900,000	27.71	$315,241	$322,833	$328,648
2010	297,716	9,571,580,000	32.15	$327,176	$345,167	$359,306
[1] WTP estimates are reported in undiscounted 1990 dollars and represent value per case.						

Illustrative Example of Income Elasticity Effect on VSL Estimate

We characterize the potential effect of income elasticity on the VSL estimate in Exhibit 5. An income elasticity of 0.08 demonstrates the effect of a slight adjustment to the VSL estimates as median income gradually rises. As shown in the exhibit, between 1990 and 2010, the VSL estimates would increase by approximately two percent. The central estimate, 0.40, demonstrates that by 2010, a thirty percent increase in median income would result in VSL increasing by approximately eleven percent. The upper bound value demonstrates the effect of assuming one as the value of income elasticity. In this twenty year period of the prospective analysis, the VSL estimate would increase from $4.8 to $6.3 million if income elasticity equals one.

Exhibit 5 ILLUSTRATIVE ADJUSTMENT TO ESTIMATES OF THE VALUE OF STATISTICAL LIFE (thousands)						
Year	US Population	Real GDP	Income	Value of Life Estimate[1]		
				Lower Bound E_y=0.08	Central Estimate E_y=0.40	Upper Bound E_y=1.0
1990	249,440	6,136,300,000	24.60	$4,800	$4,800	$4,800
2000	274,634	7,609,900,000	27.71	$4,846	$5,034	$5,407
2010	297,716	9,571,580,000	32.15	$4,904	$5,342	$6,273
[1] Value of life estimates reported in undiscounted 1990 dollars.						

CONCLUSION

The results of our review demonstrate that there is little debate over the validity of a positive income effect on WTP estimates. The empirical evidence demonstrates that while there are a wide variety of estimates available upon which to base income elasticity adjustments, there is still active debate over the strength of this effect. This memorandum outlines an approach characterizing the potentially significant effect of an income elasticity adjustment. Regardless of ranges chosen for conducting a sensitivity analysis, it is important that the 812 report include mention of two critical uncertainties:

- Many of the studies are based on data collected prior to the 1980s and several were collected outside the U.S. (e.g., the United Kingdom, Sweden, and Taiwan). These two factors present a potential for taste and preference biases. As a result, these estimates as only adequate for characterizing potential changes in WTP due to the gradual growth in median U.S. income.

- All available income elasticity measures are based on cross-sectional studies, and we propose an application for changes in income over time. SAB members and 812 project team members alike acknowledged this issue. We suggest that this limitation should not prohibit application of the literature to a sensitivity test or illustrative calculation.

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APPENDIX A

ANALYTICAL METHODS

Implementing an adjustment to WTP to reflect changes in income over time requires three pieces of information: (1) a formula to calculate changes in WTP; (2) income estimates; and (3) income elasticity of WTP estimates.

Adjustment Formula

First, we can convert the income elasticity formula discussed above into an expression that allows us to solve for changes in WTP. The conversion process follows four algebraic steps:

Conditions: Let $E_y = \varepsilon$ = income elasticity of WTP estimate
Let Q = WTP = willingness to pay for a non-priced public good
Let Y = I = income estimate

Step #1 $\varepsilon = (\Delta WTP/WTP) / (\Delta I/I) = [(WTP_2 - WTP_1) * (I_2 + I_1)] / [(I_2 - I_1) * (WTP_2 + WTP_1)]$

Step #2 $\varepsilon I_2 WTP_2 + \varepsilon I_2 WTP_1 - \varepsilon I_1 WTP_2 - \varepsilon I_1 WTP_1 = I_2 WTP_2 + I_1 WTP_2 - I_2 WTP_1 - I_1 WTP_1$

Step #3 $WTP_2 * (\varepsilon I_2 - \varepsilon I_1 - I_2 - I_1) = WTP_1 * (\varepsilon I_1 - \varepsilon I_2 - I_1 - I_2)$

Step #4 $WTP_2 = WTP_1 * [(\varepsilon I_1 - \varepsilon I_2 - I_2 - I_1) / (\varepsilon I_2 - \varepsilon I_1 - I_2 - I_1)]$

Real GDP Per Capita Estimates

Second, we can generate income estimates in terms of real GDP per capita. To calculate real GDP per capita requires two pieces of information: (1) population estimates; and (2) estimates of real GDP. We present the relevant real GDP data in Exhibit 1 below.

Exhibit A-1
CALCULATION OF REAL GDP PER CAPITA
(thousands)

Year	US Population	Change in US Population	Real GDP	Change in Real GDP	Income (Real GDP Per Capita)
1990	249,440	--	6,136,300,000	--	24.60
1991	252,124	1.1%	6,079,400,000	-0.9%	24.11
1992	255,002	1.1%	6,244,400,000	2.7%	24.49
1993	257,753	1.1%	6,389,600,000	2.3%	24.79
1994	260,292	1.0%	6,610,700,000	3.5%	25.40
1995	262,761	0.9%	6,742,100,000	2.0%	25.66
1996	265,179	0.9%	6,928,400,000	2.8%	26.13
1997	267,636	0.9%	7,163,970,000	3.4%	26.77
1998	270,002	0.9%	7,314,410,000	2.1%	27.09
1999	272,330	0.9%	7,453,380,000	1.9%	27.37
2000	274,634	0.8%	7,609,900,000	2.1%	27.71
2001	276,918	0.8%	7,777,320,000	2.2%	28.09
2002	279,189	0.8%	7,963,980,000	2.4%	28.53
2003	281,452	0.8%	8,155,110,000	2.4%	28.98
2004	283,713	0.8%	8,350,840,000	2.4%	29.43
2005	285,981	0.8%	8,542,900,000	2.3%	29.87
2006	288,269	0.8%	8,739,390,000	2.3%	30.32
2007	290,583	0.8%	8,940,400,000	2.3%	30.77
2008	292,928	0.8%	9,146,030,000	2.3%	31.22
2009	295,306	0.8%	9,356,390,000	2.3%	31.68
2010	297,716	0.8%	9,571,580,000	2.3%	32.15

Note: Income equals real GDP per capita; or Real GDP ÷ US Population.

We obtain population estimates from the US Bureau of the Census, which posts historical population figures (e.g., 1900 to 1996) and future population projections (e.g., 1996 to 2050) on their Internet web site.[10] The Congressional Budget Office (CBO) and the Bureau of Economic Analysis (BEA) release current estimates and future projections of real GDP.[11] BEA provides annual and quarterly estimates of real GDP for each year and quarter between 1929 and 1996 on their Internet web site. CBO provides projections of real GDP (in units of percent change) for each year between 1996 and 2007 on their Internet web site. Additional estimates of real GDP can be obtained from other government agencies and some private institutions.[12]

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[10] Population estimates for 1990-1997 obtained from the US Bureau of the Census, *Historical National Population Estimates: July 1,1900 to July 1, 1997*, April 2, 1998, obtained from the Internet (http://www.census.gov/population/estimates/nation/popclockest.txt) on June 22, 1998. Population projections for 1998-2010 obtained from the US Bureau of the Census, *Resident Population Projections of the United States: Middle, Low, and High Series, 1996-2050,* March 1996, obtained from the Internet (http://www.census.gov/population/projections/nation/npaltsrs.txt) on December 18, 1997. Population data cover the resident population only and reflect the "middle series" for projection years.

[11] Real Gross Domestic Product (GDP) estimates for 1990-1996 obtained from the Bureau of Economic Analysis (BEA), *Table 2A - Real Gross Domestic Product*, obtained from the Internet (http://www.bea.doc.gov/bea/dn/0897nip2/tab2a.htm) on December 18, 1997. Estimates are in chained (1992) dollars. Real GDP projections for 1997-2007 obtained from the Congressional Budget Office (CBO), *The Economic and Budget Outlook: An Update*, Table 4 - Economic Projections for Calendar Years 1997 Through 2007, September 1997, obtained from the Internet (http://www.cbo.gov/showdoc.cfm?index=31&sequence=2) on December 18, 1997. Projections reflect CBO's September 1997 outlook and are provided in units of percent change. Real GDP projections for 2008-2010 reflect the average projected growth in real GDP during the 1999-2007 period, as reported by the CBO.

[12] For information on additional sources of GDP estimates see: Memorandum to Jim DeMocker, US EPA, from Angelique Knapp and James Neumann, Industrial Economics, Inc., *Macroeconomic Forecasts for Use in CAA Section 812 Prospective Analysis*, August 6, 1997.

Attachment A

MORBIDITY STUDIES WITH INCOME OF ELASTICITY OF WTP ESTIMATES

Author	Study Location/Description	Sample Size (n)	Income Elasticity of WTP	
			MinorHealth Effect	Severe Health Effect
Alberini et al. (1997)	CV survey valuing avoided cases of acute respiratory illness (e.g., headache, runny nose, sore throat, cough, "cold"). Survey administered in Taiwan.	864		0.41 (based on "general model" of health effects)
Loehman and De (1982)	CV survey examining air pollution control in the Tampa Bay area of Florida mailed to Tampa Bay residents. The survey described respiratory health effects in terms of related symptoms (e.g., lung problems described in terms of shortness of breath).	404	0.26 (minor coughing and sneezing, eye irritation)	0.6 (severe shortness of breath)

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MORBIDITY STUDIES WITH INCOME OF ELASTICITY OF WTP ESTIMATES

Author	Study Location/Description	Sample Size (n)	Income Elasticity of WTP	
			MinorHealth Effect	Severe Health Effect
Persson *et al.* (1995)	Purpose of study was to solicit WTP to avoid nonfatal traffic injuries and compare results to WTP to avoid fatal traffic injuries. All respondents answered same questions on fatal injuries. Group I was confronted with "real risk"; Group II was confronted with twice the risk of Group I (i.e., longer durations and increased severity of injury). Survey was administered in Sweden to individuals between the ages 18 and 74 beginning in 1993.	1,000		0.25 - 0.37
Rowe and Chestnut (1985 and 1986)	Study examining changes in behavior, expenditures and WTP for variations in asthma severity. Income is a significant explanatory variable for WTP for a better chance to participate in leisure activities and for reduced discomfort if asthma improved. Data collected in Glendora, California mainly through daily diary and CV questionnaire administered to asthmatics expected to be sensitive to ambient oxidant levels.	82	0.06 (better chance to participate in leisure activities)	0.51 (reduced discomfort)

Attachment A

MORBIDITY STUDIES WITH INCOME OF ELASTICITY OF WTP ESTIMATES

Author	Study Location/Description	Sample Size (n)	Income Elasticity of WTP	
			MinorHealth Effect	Severe Health Effect
Viscusi and Evans (1993)	Consumer product safety study estimating the dependence of risk-dollar tradeoffs on income. Examined two products (insecticides and toilet bowl cleaner) and associated injuries. Reported income elasticities are: 0.17 for eye burns, 0.26 for inhalations, 0.35 for gassings, and 0.38 for skin poisonings.		0.17 (eye burns)	0.38 (skin poisonings)
Holtman and Olsen (1978)	Income elasticity is derived from a demand for health care study. These results are cited in a paper by Dickie *et. al* (1986).		0.057 - 0.30	
Manning et al. (1981)	Income elasticity is derived from a demand for health care study. These results are cited in a paper by Dickie *et. al* (1986).		0.04	
Phelps (1975)	Income elasticity is derived from a demand for health care study. These results are cited in a paper by Dickie *et. al* (1986).		0.11	

Attachment B

MORTALITY STUDIES WITH INCOME OF ELASTICITY OF WTP ESTIMATES

Author	Study Location/Description	Sample Size (n)	Income Elasticity of WTP	
			Lower Bound Estimate	Upper Bound Estimate
Blomquist (1979)	CV study on the WTP to reduce the risk of death through automobile seatbelt use. Estimate is based on 1972 data from *A Panel Study of Income Dynamics, 1968-1974.* US-based study.	5,517	0.30	0.30
Jones-Lee et al. (1985)	CV questionnaire (37 questions) on the value of safe auto travel administered in the United Kingdom.	1,103	Multiple Estimates	
	Question 14(b)	980	0.44	
	Question 20(a)	950	0.32	
	Question 20(b)	957	0.40	
	Question 20(c)	962	0.25	
Johannesson and Johansson (1997)	CV survey valuing life extension. Survey administered through telephone interviews with a random sample of Swedes between the ages of 18 to 69 years.	2,824	0.22	0.25

Attachment B

MORTALITY STUDIES WITH INCOME OF ELASTICITY OF WTP ESTIMATES

Author	Study Location/Description	Sample Size (n)	Income Elasticity of WTP	
			Lower Bound Estimate	Upper Bound Estimate
Miller and Guria (1991)	CV survey on the value of statistical life and the relative valuation of non-fatal injuries. Survey conducted as part of the Ministry of Transport's travel survey.	629	0.08	0.29
Mitchell and Carson (1986)	Valuing Drinking Water Risk Reductions Using CV methods.	237	0.35	0.35
Persson *et al.* (1995)	Purpose of study was to solicit WTP to avoid nonfatal traffic injuries and compare results to WTP to avoid fatal traffic injuries. All respondents answered the same questions on fatal injuries. Group I was confronted with "real risk"; Group II was confronted with twice the risk of Group I (i.e., longer durations and increased severity of injury).	1,000	0.46	0.46
Viscusi and Evans (1990)	Wage-risk tradeoff analysis of a 1982 chemical worker survey administered in the U.S. Income elasticity of the value of an injury in the logarithmic case is 1.1, and in the Taylor's series case is 0.67.	249	0.67	1.1