Chapter A12: Non-Use Meta-Analysis Methodology

INTRODUCTION

Comprehensive, appropriate estimates of total resource value include both use and non-use values, such that the resulting total value estimates may be compared to total social cost. "Non-use values, like use values, have their basis in the theory of individual preferences and the measurement of welfare changes. According to theory, use values and non-use values are additive" (Freeman, 1993).[1] Therefore, use values alone may seriously understate total social values. Recent economic literature provides substantial support for the hypothesis that non-use values are greater than zero. Moreover, when small per capita non-use values are held by a substantial fraction of the population, they can be very large in the aggregate. As stated by Freeman (1993), "... there is a real possibility that ignoring non-use values could result in serious misallocation of resources."

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Given that aquatic species without any direct uses account for the majority of cooling water intake structure losses, a comprehensive estimate of benefits of reduced impingement and entrainment (I&E) losses requires an estimate of non-use benefits. Stated preference methods, or benefit transfers based on stated preference studies, are the generally accepted techniques for estimating non-use values. Stated preference methods rely on surveys that assess individuals' stated willingness-to-pay (WTP) for specific ecological improvements, such as increased protection of fishery resources. Benefit transfer involves adapting research conducted for another purpose in the available literature to address the policy questions in hand (Bergstrom and De Civita, 1999). Because benefit-cost analysis of environmental regulations rarely affords sufficient time to develop original stated preference surveys specific to policy effects, benefit transfer is often the only remaining option for providing information to inform policy decisions.

Benefit transfer methods fall in three fundamental classes: 1) transfer of an unadjusted fixed value estimate generated from a single study site, 2) the use of expert judgment to aggregate or otherwise alter benefits to be transferred from a site or set of sites, and 3) estimation of a value estimator model derived from study site data, often from multiple sites (Bergstrom and De Civita, 1999). Recent studies have shown little support for the accuracy or validity of method 1, leading to increased attention to, and use of, *adjusted values* estimated by one of the remaining two approaches (Bergstrom and De Civita, 1999).

The following describes how EPA considered to apply method 3, often cited as a more appropriate means of benefit transfer, for the calculation of non-use values. Meta-analysis techniques have been increasingly explored by economists as a potential basis of policy analysis conducted by various government agencies charged with the stewardship of natural resources.

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[1] According to Freeman (1993), this additive property holds under traditional conditions related to resource levels and prices for substitute goods in the household production model.

Despite the increasing application of such methods, there are few generally accepted guidelines for meta-analyses applied to environmental policy. EPA believes that this is a promising methodology for policy valuation. However, EPA did not include the results of this approach in the benefit analysis of the final section 316(b) regulation because of limitations and uncertainties associated with estimation of non-use benefits on a national scale.

The first step in implementing an "adjusted value" benefit transfer approach for estimating non-use values of environmental regulations is a systematic analysis of the available economic studies that estimate non-use values. EPA explored available evidence concerning total benefits (including use and non-use values) applicable to the section 316(b) regulation. EPA identified 33 surface water valuation studies that used either stated preference or a combination of stated and revealed preference techniques to elicit total (including use and non-use) benefit values of aquatic habitat improvements. These studies vary in several respects, including the specific environmental change valued, the types of values estimated, the geographic region affected by environmental changes, and survey administration methods.

To examine the relative influence of study, economic and resource characteristics on WTP for aquatic habitat improvements (specifically, water quality improvements that would benefit various species groups), the Agency conducted two regression-based meta-analyses of over 78 WTP estimates for improvements to water resources, provided by the 33 original studies.[2] The estimated econometric models can be used to calculate a range of non-use values of aquatic resources that are potentially affected by I&E.

The following discussion summarizes results of EPA's analysis of surface water valuation studies and outlines the methodology for applying meta-regression results to estimating the benefits from reduced I&E attributable to the section 316(b) regulation.

A12-1 Literature Review Procedure and Organization

EPA performed an in-depth search of the economic literature to identify valuation studies that estimate total WTP for quality changes that affect aquatic life habitats and/or recreational fishing and other recreational uses. EPA used a variety of sources and search methods to identify relevant literature:

- Review of EPA's research and bibliographies dealing with non-market benefits associated with water quality changes;
- Selection of surface water valuation studies from a meta-analysis conducted by Brown (1993), which includes valuation studies addressing a wide range of resources, all of which present separate estimates of non-use value;
- Systematic review of recent issues of resource economics journals (e.g., *Land Economics*, *Marine Resource Economics*, *Journal of Environmental Economics and Management*);
- Searches of online reference and abstract databases (e.g., Environmental Valuation Resource Inventory (EVRI), Benefits Use Valuation Database (BUVD), AgEcon Search);
- Visits to homepages of authors known to have published contingent valuation studies and or water quality research;
- Searches of Web sites of agricultural and resource economics departments at several colleges and universities; and
- Searches of Web sites of organizations and agencies known to publish environmental and resource economics valuation research [e.g., Resources for the Future (RFF), National Center for Environmental Economics (NCEE), Natural Resource Conservation Service (NRCS), National Bureau of Economic Research (NBER)].

From this review, EPA identified approximately 300 surface water valuation studies that are potentially relevant for this analysis, and compiled a bibliographic database to organize the literature review process. Thirty-four of these studies met the criteria identified for inclusion in the meta-analysis, which are as follows:

- **Specific amenity valued:** Selected studies were limited to those in which the environmental quality change being valued affects aquatic life and/or habitat in a waterbody that provides recreational fishing uses or other recreational activities, such as boating, swimming, or wildlife viewing;
- **U.S. studies:** Selected studies were limited to those that surveyed U.S. populations to value domestic resources; and
- **Research methods:** Selected studies were limited to those that applied research methods supported by journal literature.

[2] Meta-analysis is "the statistical analysis of a large collection of results for individual studies for the purposes of integrating the findings" (Glass, 1976).

Based on these criteria, the Agency obtained the full text articles of the 33 studies that seemed most relevant for benefit transfer and compiled extensive information from the selected studies. The complete data set used in the meta-analysis is provided in the public record for the final rule (see DCN #6-2900), and includes the following information:

- full study citation;
- study location;
- sample data and description (e.g., size, response rate, income);
- resource characteristics (e.g., affected waterbody type, recreational uses, baseline quality);
- environmental quality change description, including geographic scale, affected species, and affected recreational uses (i.e., 50 percent increase in catch rates or water quality change from fishable to boatable);
- quantitative measure of environmental quality change (measured on quantitative scale based on the RFF water quality ladder);
- study WTP values updated to 2002 dollars; and
- WTP estimation characteristics (i.e., parametric vs. nonparametric, inclusion of protest bids and outlier bids, WTP description).

A12-2 Description of Studies

As noted above, EPA selected 33 surface water valuation studies that allow estimation of total values from aquatic habitat improvements. These studies were conducted between 1973 and 2001, and applied standard, generally accepted valuation methods (mostly stated preference techniques) to assess WTP.[3] Studies were excluded if they did not conform to general tenets of economic theory, or if they applied methods not generally accepted in the literature.

All selected studies focus on environmental quality changes that affect surface water resources in the contiguous U.S. Beyond this general similarity, the studies vary in several respects. Differences include the specific environmental change valued, the scale of environmental improvement, the geographic region affected by environmental changes, the types of values estimated, survey administration methods, demographics of the survey sample, and statistical methods employed. The 33 studies include 17 journal articles, seven reports, four Ph.D. dissertations, three academic or staff papers, one book, and one Master's thesis. Two studies (Whitehead et al., 1995; and Whitehead and Groothuis, 1992) had the same primary author and a total of nine individuals appear as an author on more than one study.

The 33 studies selected for the meta-analysis provided 78 observations in the final data set because multiple estimates of WTP were available from 23 studies. Some of the characteristics that allowed multiple observations to be derived from a single study include the extent of the amenity change, the respondent population type, elicitation method(s), waterbody type, number of waterbodies affected, recreational activities affected by the quality change, and species affected by the quality change. Table A12-1 lists key study and resource characteristics and indicates the number of observations derived from each study.

Surveys in 20 studies were administered by mail; seven studies collected information through personal interviews in the home, on-site, or in a centralized location; and six surveys were conducted by telephone. Survey response rates range from 25 to 90 percent, and study sample sizes range from 109 to 2,907 responses.

The two most common methods for eliciting WTP values were the dichotomous choice method, used in 12 studies, and the open-ended response used in 8 studies. Seven studies used the payment card approach, and 3 used the iterative bidding method. Two studies used multiple elicitation methods to generate a single WTP estimate.[4]

[3] All of the selected studies used contingent valuation surveys (either discrete choice or open-ended), except for one study, which is based on a conjoint analysis survey. One study presented combined revealed and stated preference techniques in addition to contingent valuation results.

[4] The number of studies employing each elicitation technique does not sum to the total number of studies because some studies used different elicitation methods, from which multiple observations were derived.

Table A12-1: Select Characteristics of Surface Water Valuation Studies Used in Meta-Analysis[a]

Author and Year	Number of Observations	State	Waterbody Type	Affected Species	Affected Recreational Uses[b]
Aiken (1985)	1	CO	all freshwater	game fish	fishing
Anderson and Edwards (1986)	1	RI	salt pond/marshes	unspecified	fishing and swimming
Azevedo et al. (2001)	5	IA	lake	game fish	fishing and swimming
Bockstael et al. (1989)	2	MD	estuary	unspecified	swimming
Cameron and Huppert (1989)	1	CA	river/stream	game fish	game fishing
Carson et al. (1994)	2	CA	estuary	game fish; multiple categories	fishing
Clonts and Malone (1990)	3	AL	river/stream	unspecified	multiple uses
Croke et al. (1986-1987)	9	IL	river/stream	all recreational fish; none	boating and fishing; boating; other
Cronin (1982)	4	DC	river/stream	all recreational fish	fishing and swimming; boating
De Zoysa (1995)	2	OH	lake; river and lake	multiple categories	multiple uses
Desvousges et al. (1983)	2	PA	river/stream	unspecified	boating
Hayes et al. (1992)	2	RI	estuary	shellfish; none	fishing; swimming
Herriges et al. (1996)	2	IA	lake	all recreational fish	boating and fishing
Huang et al. (1997)	2	NC	estuary	multiple categories	fishing
Kaoru (1993)	1	MA	salt pond/marshes	shellfish	fishing
Lant and Roberts (1990)	3	IA/IL	river/stream	game fish; all recreational fish	boating, fishing, and swimming; boating and fishing
Loomis (1996)	1	WA	river/stream	game fish	fishing
Lyke (1993)	2	WI	lake	game fish	fishing
Magat et al. (2000)	2	CO/NC	all freshwater	all aquatic species	fishing; fishing and swimming
Matthews et al. (1999)	2	MN	river/stream	all aquatic species	boating and fishing
Mitchell and Carson (1981)	1	National	all freshwater	all aquatic species	fishing
Olsen et al. (1991)	3	Pacific NW (ID, MT, OR, WA)	river/stream	game fish	fishing
Roberts and Leitch (1997)	1	MN/SD	lake	multiple categories	multiple uses
Rowe et al. (1985)	1	CO	river/stream	game fish	boating, fishing, and swimming
Sanders et al. (1990)	4	CO	river/stream	unspecified	swimming
Schulze et al. (1995)	2	MT	river and lake	multiple categories	boating, fishing, and swimming
Stumborg et al. (2001)	2	WI	lake	multiple categories	multiple uses
Sutherland and Walsh (1985)	1	MT	river and lake	unspecified	swimming

Table A12-1: Select Characteristics of Surface Water Valuation Studies Used in Meta-Analysis[a]

Author and Year	Number of Observations	State	Waterbody Type	Affected Species	Affected Recreational Uses[b]
Welle (1986)	6	MN	all freshwater	multiple categories; game fish	game fishing and wildlife viewing; game fishing
Wey (1990)	2	RI	salt pond/marshes	shellfish	other
Whitehead and Groothuis (1992)	3	NC	river/stream	all recreational fish	multiple uses
Whitehead et al. (1995)	2	NC	estuary	multiple categories	boating, fishing, and swimming
Whittington et al. (1994)	1	TX	estuary	all aquatic species	multiple uses

[a] Where multiple observations are available from a given study, waterbody type, affected species, and/or affected recreational uses may take on different values for different observations from that study. In such cases where characteristics vary within a single study, these different characteristics are listed. For example, “boating, fishing, and swimming; boating and fishing,” represents a study where one or more observations from a given study dealt with quality changes that affected boating, fishing, and swimming, and at least one other observation from the same study dealt with boating and fishing.
[b] “Multiple uses” signifies that the water quality change would affect a wide variety of uses. For most of the studies with this designation, the uses were unspecified.

Source: U.S. EPA analysis for this report.

The Agency's review of the relevant economic literature showed that available surface water valuation studies focus primarily on water quality changes. Only 5 of the 33 studies specified environmental quality change in terms of increased fish abundance or harvest. In addition, 2 studies valued changes in the number of acres of shellfish beds. However, most of the reviewed studies (22) focusing on water quality improvements indicated these improvements would affect recreational fishing among other uses, and 24 studies specifically indicated that water quality improvements would affect fish abundance or diversity.

From these 33 studies, the Agency compiled a data set for the meta-analysis of WTP values. EPA specified two regression models based on these data to estimate a range of household non-use benefits. These two models include a model based on a semi-log functional form and a model based on a log-log specification. Section A12-3 focuses on the semi-log model; the alternative log-log specification is presented in section A12-4. Based on the peer-review results (see DCN 6-2500), the semi-log specification can be used in the main analysis of policy alternatives; the log-log specification can be used in a sensitivity analysis.

A12-3 Semi-Log Meta-Analysis Regression Model

EPA estimated a semi-log model based on 78 WTP estimates for improvements in water resources, derived from 33 original studies. These meta-data, the model specification, model results, and interpretation of results, are described in sections A12-3.1 through A12-3.3.

In a frequently cited work, Glass (1976) characterizes meta-analysis as "the statistical analysis of a large collection of results for individual studies for the purposes of integrating the findings. It provides a rigorous alternative to the casual, narrative discussion of research studies which is commonly used to make some sense of the rapidly expanding research literature" (p. 3; cited in Poe et al. (2001), p. 138). Meta-analysis is being increasingly explored as a potential means to estimate resource values in cases where original targeted research is impractical, or as a means to reveal systematic components of WTP (e.g., Poe et al., 2001; Bateman and Jones, 2003; Santos, 1998; Rosenberger and Loomis, 2000a; Smith and Osborne, 1996; Woodward and Wui, 2001). While the literature urges caution in the use and interpretation of benefit transfers for direct policy application (e.g., Poe et al., 2001; Desvousges et al., 1998), such methods are "widely used in the United States by government agencies to facilitate benefit-cost analysis of public policies and projects affecting natural resources" (Bergstrom and De Civita, 1999). Transfers based on meta-analysis are likewise common in both the United States and Canada (Bergstrom and De Civita, 1999).

Depending on the suitability of available data, a meta-analysis can provide a superior alternative to the calculation and use of a simple arithmetic mean WTP over the available observations, as it allows estimation of the systematic influence of study, economic, and natural resource attributes on WTP. The primary advantage of a regression-based (statistical) approach is that it accounts for differences among study characteristics that may contribute to changes in WTP, to the extent permitted by available data. An additional advantage is that meta-analysis can reveal systematic factors influencing WTP, allowing assessments of whether, for example, WTP estimates are (on average) sensitive to scope (Smith and Osborne, 1996).

A12-3.1 Meta-Data for Semi-Log Model

Meta-analysis is largely an empirical, data-driven process, but one in which variable and model selection is guided by theory. Given a reliance on information available from the underlying studies that comprise the meta-data, meta-analysis models most often represent a middle ground between model specifications that would be most theoretically appropriate and those specifications that are possible given available data. Poe et al. (2001), Bateman and Jones (2003), Rosenberger and Loomis (2000a), Smith and Osborne (1996), Dalhuisen et al. (2003), and others provide insight into the mechanics of specifying and estimating meta-equations in resource economics applications.

Past meta-analyses have incorporated a range of different statistical methods, with none universally accepted as superior (e.g., Poole and Greenland, 1999; Bateman and Jones, 2003; Poe et al., 2001; Santos, 1998). Nonetheless, the model is estimated following standard methods illustrated in the most recent literature. For example, there is significant consensus that models must somehow address (or at a minimum, test for) potential correlation among observations provided by like authors or studies and the related potential for heteroskedasticity (Bateman and Jones, 2003; Rosenberger and Loomis, 2000b). EPA followed recent work of Bateman and Jones (2003) in applying a multilevel model specification to the meta-data, to address potential correlation among observations gathered from single studies. Also following prior work (e.g., Poe et al., 2001; Smith and Osborne, 1996) EPA applied the Huber-White robust variance estimation. As described by Smith and Osborne

(1996, p. 293), "this approach treats each study as the equivalent of a sample cluster with the potential for heteroskedasticity…across clusters." Weighted models are avoided following the arguments of Bateman and Jones (2003). For comparison, models were also estimated using ordinary least squares (OLS) with robust variance estimation, weighted least squares (WLS) with robust variance estimation, and multilevel models with standard (non-robust) variance estimation. None of these models outperformed the illustrated model in terms of overall model significance and fit, and statistical significance of individual coefficients (see section A12-3.2 for further details concerning the specification of the semi-log model).

To guide development of the semi-log model and variable specifications, EPA relied upon a set of general principles. These principles are designed to help prevent excessive data manipulations and other factors that may lead to misleading model results. The general principles include, all else being equal:

- Fewer and simpler data transformations are preferred to more extensive ones;
- In the absence of overriding theoretical considerations, continuous variables are generally preferred to discrete variables derived from underlying continuous distributions;
- Models should attempt to capture elements of scope and scale of resource changes;
- Models should distinguish WTP associated with different types of resources and resource uses, particularly where relevant to the policy question at hand; and
- Where possible, exogenous constraints should be avoided in favor of "letting the data speak for themselves."

The dependent variable in the meta-analysis is the natural logarithm of estimated household WTP for water quality improvements in aquatic habitat, as reported in each original study. For this analysis, original study values were adjusted to 2002$ based on the relative change in Consumer Price Index (CPI) from the study year to 2002. Total WTP over the sample ranged from $7.26 to $376.61, with a mean value of $110.70. As expected, WTP for non-users had a lower mean value of $86.60, with a range from $27.74 to $242.34.[5]

All right-hand-side variables are linear, resulting in a standard semi-log functional form. This functional form has advantages because of 1) its fit to the data, 2) the intuitive results provided by the functional form, and 3) the common use of this functional form in the meta-analysis literature (e.g., Smith and Osborne, 1996; Santos, 1998). While linear forms are also common in this literature (Bateman and Jones, 2003; Poe et al., 2001; Rosenberger and Loomis, 2000a,b), specifications requiring more intensive data transformations (e.g., Box-Cox, log-log) are less common.

As noted in the preceding section, the meta-data include independent variables characterizing specifics of the resource(s) valued such as the baseline resource conditions; the extent of resource improvements and whether they occur in estuarine or freshwater; the geographic region and scale of resource improvements (e.g., the number of waterbodies); elicitation and survey methods; characteristics of surveyed populations (e.g., users, non-users); and other specifics of each study. For ease of exposition, these variables are categorized into those characterizing 1) study and methodology, 2) surveyed populations, 3) geographic region and scale, and 4) resource improvements. Attributes included within each category are summarized below.

Study and methodology variables characterize such features as:

- The year in which a study was conducted;
- The payment vehicle and elicitation format (e.g., discrete choice versus open-ended, voluntary versus non-voluntary, interview versus mail versus phone);
- WTP estimation methods and conventions (e.g., approaches to protest and outlier bids, use of parametric versus nonparametric statistical methods, estimation of mean or median WTP, the use of annual or lump-sum payments);
- Reported survey response rates; and
- Whether the original survey represented water quality changes using the Resources for the Future water quality ladder.

Surveyed populations variables characterize such features as:

- The average income of respondents; and
- Whether the survey specifically targeted non-users.

[5] EPA notes that only 10 of the 33 studies provided WTP values for non-users.

Geographic region and scale variables characterize such features as:

- The number of waterbodies affected by the policy; and
- The geographic area of the country in which the study was conducted.

Resource improvement variables characterize such features as:

- The extent of water quality change affecting different species groups;
- Baseline water quality;
- Those studies for which changes in uses other than fishing are specifically noted in the survey;
- Those studies identifying large increases in fish populations (i.e., greater than 50 percent); and
- Those studies in which the resource improvements are described (within the associated survey) as affecting uses that are not directly affected by improvements in fishery resources (e.g., outing and swimming).

Although the interpretation and calculation of most independent variables requires little explanation, a few variables require additional detail. These include the variables characterizing surface water quality and its measurement. Many (23) observations in the meta-data characterize quality changes using variants of the RFF water quality ladder (e.g., Mitchell and Carson, 1989). This scale is linked to specific pollutant levels which, in turn, are linked to presence of aquatic species and recreational uses. However, some observations provide water quality measures using other, primarily descriptive, means that differ from the RFF water quality ladder.

To allow consistent comparisons of water quality change using a single scale, EPA mapped all water quality measures to the original water quality scale (or ladder) developed and tested by RFF. Water quality ladder values were therefore developed for those studies that did not originally use the RFF ladder. This scale was chosen for two reasons. First, a large number of the original studies in the meta-data included RFF ladder measures as “native” components of the original surveys. Hence, for these studies, no additional transformations were required. Second, it was decided that the use of an existing, well-tested and accepted water quality index was in general superior to the development of a unique scale for this study.

While not all studies in the meta-data included the RFF ladder as a native survey component, in most cases the descriptions of water quality (present in the studies that did not apply the water quality ladder) rendered mapping of water quality measures to the RFF ladder straightforward. In cases where baseline and improved (or declined) water quality was not defined by suitability for recreational activities (e.g., boating, fishing, swimming) or corresponding qualitative measures (e.g., poor, fair, good), EPA used descriptive information available from studies (e.g., amount/indication of the presence of specific pollutants, historical decline of the quality of the resource) to approximate the baseline level of water quality and the magnitude of the change.[6] For studies that valued discrete changes in the size of species populations, EPA characterized the baseline quality based on the current presence and prevalence of the species at hand, and assumed population increases to correspond to modest increases in water quality in order to be conservative.[7] To account for the uncertainty involved in mapping those studies that are not based on the RFF water quality ladder, EPA introduced the binary variable *wq_ladder*, which indicates those studies in which water quality ladder measurements were an original component of the survey instrument.

Variables incorporated in the final model are listed and described in Table A12-2.

[6] For example, a study by Huang et al. (1997) described current water quality as degraded from 1981 levels in terms of reduced fish catches (60 percent) and reduced number of open shellfish beds (25 percent). However, because the water resource was still supporting recreational fishery, the baseline water quality was set to “fishable” on the water quality ladder.

[7] For example, a study by Lyke (1993) describes the baseline conditions as follows: (1) “there are no naturally reproducing lake trout in Lake Michigan; all lake trout found there are from hatcheries.” 2) “Lake Superior stocks of self-reproducing lake trout were much reduced, but not wiped out, and both natural and hatchery-raised lake trout are found there.” These baseline conditions correspond to the “game-fishable” level on the water quality ladder. The study estimates WTP for restoring natural populations of lake trout to the Wisconsin Great Lakes. Therefore, the expected change that will occur within the “game-fishable” category is likely to be small.

Table A12-2: Variables and Descriptive Statistics for the Semi-Log Regression Model

Variable	Description	Units and Measurement	Mean (Std. Dev.)
ln_WTP	Natural log of WTP for specified resource improvements.	Natural log of dollars (Range: 1.98 to 5.93)	4.45 (0.78)
year_indx	Year in which the study was conducted, converted to an index by subtracting 1,970.	Year index (Range: 3 to 31)	18.51 (6.54)
discrete_ch	Binary (dummy) variable indicating that WTP was estimated using a discrete choice survey instrument.	Binary (Range: 0 or 1)	0.32 (0.47)
voluntary	Binary (dummy) variable indicating that WTP was estimated using a payment vehicle described as voluntary as opposed to, for example, property taxes.	Binary (Range: 0 or 1)	0.08 (0.27)
interview	Binary (dummy) variable indicating that the survey conducted through in-person interviews (default value for this dummy is a phone survey).	Binary (Range: 0 or 1)	0.19 (0.40)
mail	Binary (dummy) variable indicating that the survey was conducted through mail (default value for this dummy is a phone survey).	Binary (Range: 0 or 1)	0.54 (0.50)
lump_sum	Binary (dummy) variable indicating that payments were to occur on something other than an annual basis over a long period of time, such as property taxes. For example, some studies specified that payments would occur over a five-year period.	Binary (Range: 0 or 1)	0.18 (0.39)
nonparam	Binary (dummy) variable indicating that WTP was estimated using nonparametric methods.	Binary (Range: 0 or 1)	0.47 (0.50)
wq_change	Change in mean water quality, specified on the RFF water quality ladder (Mitchell and Carson, 1989). Defined as the difference between baseline and post-compliance quality. Where the original study (survey) did not use the RFF water quality ladder, EPA mapped water quality descriptions to analogous levels on the RFF ladder to derive water quality change (see text). Note that this variable was only included in the final model as part of an interaction term (*WQ_fish*, *WQ_shell*, *WQ_many*, *WQ_non*).	Water quality ladder units (Range: 0.5 to 5.75)	2.45 (1.06)
wq_ladder	Binary (dummy) variable indicating that the original survey reported resource changes using a standard RFF water quality ladder.	Binary (Range: 0 or 1)	0.29 (0.46)
protest_bids	Binary (dummy) variable indicating that protest bids were excluded when estimating WTP.	Binary (Range: 0 or 1)	0.47 (0.50)
outlier_bids	Binary (dummy) variable indicating that outlier bids were excluded when estimating WTP.	Binary (Range: 0 or 1)	0.23 (0.42)
median_WTP	Binary (dummy) variable indicating that the study reported median, not mean, WTP.	Binary (Range: 0 or 1)	0.06 (0.25)
hi_response	Binary (dummy) variable indicating that the survey response rate exceeds 74 percent (i.e., 75 percent or above).	Binary (Range: 0 or 1)	0.32 (0.47)
income	Mean income of survey respondents, either as reported by the original survey or calculated by EPA based on U.S. Census Bureau averages for the original surveyed region.	Dollars (Range: 30,396 to 137,693)	47,189.37 (13,010.15)
nonusers	Binary (dummy) variable indicating that the survey is implemented over a population of non-users (default category for this dummy is a survey of any population that includes users).	Binary (Range: 0 or 1)	0.19 (0.40)
single_river[a]	Binary (dummy) variable indicating that resource change explicitly takes place over a single river (default is a change in an estuary).	Binary (Range: 0 or 1)	0.21 (0.41)
single_lake[b]	Binary (dummy) variable indicating that resource change explicitly takes place over a single lake (default is a change in an estuary).	Binary (Range: 0 or 1)	0.13 (0.34)
multiple_river	Binary (dummy) variable indicating that resource change explicitly takes place over multiple rivers (default is a change in an estuary).	Binary (Range: 0 or 1)	0.09 (0.29)

Table A12-2: Variables and Descriptive Statistics for the Semi-Log Regression Model

Variable	Description	Units and Measurement	Mean (Std. Dev.)
salt_pond	Binary (dummy) variable indicating that resource change explicitly takes place over multiple salt ponds (default is a change in an estuary).	Binary (Range: 0 or 1)	0.05 (0.22)
num_riv_pond	Number of rivers or salt ponds affected by policy; if unspecified *num_riv_pond* = 0. (In the present data, only studies addressing rivers and lakes specified >1 number of waterbodies. All others specified either 1 waterbody, or the number was unspecified.)	Number of specified rivers or ponds (Range: 0 to 15)	1.41 (3.63)
regional_fresh	Binary (dummy) variable indicating that resource change explicitly takes place in a fresh waterbody (default is a change in a salt waterbody or an estuary).	Binary (Range: 0 or 1)	0.37 (0.49)
southeast	Binary (dummy) variable indicating that survey was conducted in the USDA southeast region (default is northeast region).	Binary (Range: 0 or 1)	0.13 (0.34)
pacif_mount	Binary (dummy) variable indicating that survey was conducted in the USDA pacific/mountain region.	Binary (Range: 0 or 1)	0.21 (0.41)
plains	Binary (dummy) variable indicating that survey was conducted in the USDA northern or southern plains region.	Binary (Range: 0 or 1)	0.03 (0.16)
mult_reg	Binary (dummy) variable indicating that survey included respondents from more than one of the section 316(b) regions.	Binary (Range: 0 or 1)	0.04 (0.19)
WQ_fish	Interaction variable: *wq_change* multiplied by a binary (dummy) variable identifying studies in which water quality improvements are stated to benefit only fin fish species.[c] Default is zero (i.e., water quality change did not affect fish).	Water quality ladder units (Range: 0.5 to 5.75)	1.13 (1.54)
WQ_shell	Interaction variable: *wq_change* multiplied by a binary (dummy) variable identifying studies in which water quality improvements are stated to benefit only shellfish.[c] Default is zero (i.e., water quality change did not affect shellfish).	Water quality ladder units (Range: 0.5 to 4.0)	0.13 (0.65)
WQ_many	Interaction variable: *wq_change* multiplied by a binary (dummy) variable identifying studies in which water quality improvements are stated to benefit multiple species types (including fish, shellfish, and birds).[c] Default is zero (i.e., water quality change did not affect multiple species).	Water quality ladder units (Range: 0.5 to 4.0)	0.65 (1.21)
WQ_non	Interaction variable: *wq_change* multiplied by a binary (dummy) variable identifying studies in which species benefitting from water quality improvements remain unspecified.[c] Default is zero (i.e., water quality change affected specified species).	Water quality ladder units (Range: 0.5 to 2.5)	0.53 (0.94)
nonfish_uses	Binary (dummy) variable identifying studies in which changes in uses other than fishing are specifically noted in the survey.	Binary (Range: 0 or 1)	0.76 (0.43)
fishplus	Binary (dummy) variable identifying studies in which a fish population or harvest change of 50 percent or greater is reported in the survey.	Binary (Range: 0 or 1)	0.13 (0.34)
baseline	Baseline water quality, specified on the RFF water quality ladder.	Water quality ladder units (Range: 0 to 7)	4.66 (2.49)

[a.] Examples of rivers and streams considered in the studies include the Columbia, Potomac, Elwha, Eagle, and Tar-Pamlico rivers.
[b] Includes one study that focused on a segment of the Lake Erie shoreline.
[c] The variable *wq_change* is defined earlier in this table as the difference between baseline and post-compliance quality, specified on the RFF water quality ladder (Mitchell and Carson, 1989).

Source: U.S. EPA analysis for this report.

A12-3.2 Semi-Log Model and Results

a. Semi-log model

As noted above, EPA estimated the meta-analysis regression using a multilevel, random-effects specification. This model follows the general approach of Bateman and Jones (2003). Multilevel (or hierarchical) models may be estimated as either random-effects or random-coefficients models, and are described in detail elsewhere (Goldstein, 1995; Singer, 1998). The fundamental distinction between these and classical linear models is the two-part modeling of the equation error to account for hierarchical data. Here, the meta-data are comprised of multiple observations per study, and there is a corresponding possibility of correlated errors among observations that share a common study or author.

The common approach to modeling such potential correlation is to divide the residual variance of estimates into two parts, a random error that is independently and identically distributed across all studies and for each observation, and a random effect that represents systematic variation related to each study. The model is estimated as a two-level hierarchy, with level one corresponding to non-use value estimates (individual observations), and level two corresponding to individual studies. The random-effect may be interpreted as a deviation from the mean equation intercept associated with individual studies (Bateman and Jones, 2003). The model is estimated using a maximum likelihood estimator (MLE), assuming that random effects are distributed multivariate normal. Following Bateman and Jones (2003), observations are unweighted. Covariances are obtained using the Huber-White covariance estimator (Smith and Osborne, 1996). Random-effects models such as the multilevel model applied here are becoming increasingly standard in resource economics applications, and are estimable using a variety of readily available software packages.

❖ ***A note on functional form***

The dependent variable in the semi-log model is the natural log of WTP for surface water quality improvement, as shown by Table A12-2. The combination of this dependent variable with linear independent variables results in a common semi-log functional form. This functional form was chosen based on a combination of theoretical and empirical factors. Of particular importance was the performance of the semi-log model with regard to 1) data fit, 2) intuitive nature of results, and 3) history in the meta-analysis literature (e.g., Smith and Osborne, 1996; Santos, 1998).

The semi-log model was chosen over the linear model based on the ability of the semi-log form to capture curvature in the valuation function and its improved fit to the data. It also allows independent variables to influence WTP (after transformation from its natural log) in a multiplicative rather than additive manner.

The choice between log-log and semi-log functional forms is somewhat less straightforward. An appropriately specified log-log model has the theoretical advantage of requiring WTP to be zero when quality change is also equal to zero. The semi-log model does not impose this exogenous restriction. However, in the present context, it is questionable whether this restriction is justified by the meta-data. Average WTP in the data is approximately $111, with WTP values in the lowest 95th percentile of approximately $21. There are no zero WTP values in the data, and no studies for which water quality change approaches zero. Hence, the extreme low-end of any model specification forecasts beyond the range of available data. The ability of a model specification to restrict the WTP equation at a point beyond the reach of the available data may be of questionable empirical value — particularly given that threshold effects or nonconvexities may influence WTP at extremely low levels of quality change.

Given the questions about *a priori* restrictions on the functional form, final decisions regarding functional forms were made based on a combination of general principles and empirical performance. Based on these criteria, the semi-log model seems to outperform the log-log model. First, EPA used the Box-Cox method to see wether the data suggest linear independent variables or log dependent variables.[8] The Box-Cox test rejected the log specification. Moreover, the overall significance level of many variables is better in the semi-log model, including key variables characterizing such features as baseline water quality, water quality change, and the number of waterbodies affected by a policy.

From an empirical standpoint, another benefit of the semi-log specification is that it provides intuitive forecasts of WTP for marginal (small) quality changes at the low end of the data. For example, using the final semi-log specification, the difference in WTP between a 1 percent and 3 percent improvement in water quality (a barely perceptible difference for most

[8] EPA estimated the Box-Cox exponent (*Lambda*) for the independent variables only. In addition, the Box-Cox transformation was only tested for continuous variables (i.e., dummy variables were not transformed, following standard practice). The Box-Cox test strongly rejects the log-log specification (*Lambda*= 0); it also strongly rejects the multiplicative inverse specification of independent variables (*Lambda*= -1). However, it fails to reject the semi-log specification, or linear specification of independent variables (*Lambda*=1).

respondents) is fairly small: far less than $1 in most model specifications. In contrast, log-log models tend to forecast fairly large relative changes in WTP for very small changes in water quality improvements.

❖ *A note on model specification*

Following standard econometric practice, the final model is specified based on guidance from theory and prior literature. For example, Arrow et al. (1993) make a fundamental distinction between discrete choice and open-ended payment mechanisms (where open ended include iterative bidding, payment cards, etc.). Hence, this is the distinction made in the final model (i.e., including the variable *discrete_ch*). Similarly, other "survey methodology" variables in the model were chosen based on theoretical considerations and prior findings in the literature (e.g., voluntary vs. mandatory payment vehicles, parametric vs. non-parametric, treatment of protest and outlier bids, use of mean versus median WTP).

Few variables were excluded solely because of lack of statistical significance. Individual variables were only excluded if they could not be shown to be statistically significant in any version of the model (restricted or unrestricted), and there was no overriding rationale for retaining the variable in the model. For example, variables distinguishing different *types* of discrete choice instruments (e.g., conjoint vs. dichotomous choice) added no significant explanatory power to the model (p=0.44).

Another example of excluded variables involves a set of variables identifying waterbody uses. While the model includes a key variable (*nonfish_uses*) distinguishing studies in which non-fishing uses were emphasized, the model excludes variables characterizing *specific* uses of included waterbodies. These variables are suppressed for a variety of reasons. First, substantial variability of types and magnitudes of uses present in the 78 different observations prevented a simple characterization of specific uses in a reasonable number of variables. Attempts to approximate such effects using information available in the original published studies produced unsatisfactory results — the associated variables were insignificant as a group in all model variants (tested as a group in the final model, χ^2=9.04 with df=8, such that p=0.31). Moreover, the primary purpose of the model is to assess non-use values for habitat improvements (affecting fish) in "average" waterbodies supporting a variety of uses.

It is important to note that although empirical considerations certainly play a role in model development, certain variables were retained in the model for theoretical reasons, even if significance levels were low. Such specification of meta-analysis models using a combination of theoretical guidance and empirical considerations is standard in modeling efforts.

b. Semi-log model results

Table A12-3 presents results of the semi-log model.

Table A12-3: Estimated Multilevel Model Results for the Semi-Log Model: WTP for Aquatic Habitat Improvements

Variable	Parameter Estimate	Standard Error	t Value	Prob > |t|
intercept	6.0158	0.6163	9.7600	<.0001
year_indx	-0.1072	0.0187	-5.7400	<.0001
discrete_ch	0.3956	0.3728	1.0600	0.2961
voluntary	-1.6330	0.2441	-6.6900	<.0001
interview	1.3252	0.2330	5.6900	<.0001
mail	0.5666	0.1774	3.1900	0.0030
lump_sum	0.5954	0.2526	2.3600	0.0243
nonparam	-0.4472	0.2228	-2.0100	0.0527
wq_ladder	-0.3799	0.2069	-1.8400	0.0751
protest_bids	0.9537	0.1580	6.0400	<.0001
outlier_bids	-0.8764	0.1212	-7.2300	<.0001
median_WTP	0.2206	0.1625	1.3600	0.1836
hi_response	-0.8094	0.1223	-6.6200	<.0001
income	0.0000	0.0000	0.1100	0.9128
nonusers	-0.5017	0.1189	-4.2200	0.0002
single_river	-0.3378	0.2189	-1.5400	0.1321
single_lake	0.3193	0.2723	1.1700	0.2492
multiple_river	-1.6050	0.3020	-5.3200	<.0001
salt_pond	0.7574	0.3650	2.0800	0.0456
num_rivers_ponds	0.0791	0.0094	8.4100	<.0001
regional_fresh	-0.0073	0.1664	-0.0400	0.9655
southeast	1.1482	0.2175	5.2800	<.0001
pacif_mount	-0.3125	0.1329	-2.3500	0.0246
plains	-0.8153	0.3173	-2.5700	0.0147
mult_reg	0.5951	0.2548	2.3400	0.0256
WQ_fish	0.2055	0.0861	2.3900	0.0227
WQ_shell	0.2561	0.0999	2.5600	0.0149
WQ_many	0.2332	0.1107	2.1100	0.0426
WQ_non	0.4695	0.2117	2.2200	0.0334
nonfish_uses	-0.1412	0.1841	-0.7700	0.4484
fishplus	0.8052	0.1951	4.1300	0.0002
baseline	-0.1265	0.0425	-2.9800	0.0053
Error Term (σ^2)	0.1151			
-2 Log Likelihood	65.6			
Covariance Factors:				
Study Level (σ_u)	6.19×10^{-18}			
Residual (σ_e)	0.1357			

Source: U.S. EPA analysis for this report.

A12-3.3 Interpretation of Semi-Log Regression Analysis Results

Regression results reveal strong systematic elements influencing WTP. The analysis finds both statistically significant and intuitive patterns that influence WTP for water quality improvements in aquatic habitats. In general, the statistical fit of the equation is quite good; there is a strong systematic element of WTP variation that allows forecasting of WTP based on site and study characteristics. The model as a whole is statistically significant at $p<0.0001$. The adjusted R-square is 0.77. Of the 31 independent variables in the restricted model (not including the intercept), 24 are statistically significant at the 10 percent level, with most statistically significant at the 1 percent level. Signs of significant parameter estimates generally correspond with intuition, where prior expectations exist. As shown in Table A12-3, the random effect is statistically insignificant (i.e., study level covariance factors are essentially zero). Considering these factors, the statistical fit of the semi-log model compares quite favorably to prior meta-analyses present in the literature.

a. Resource improvement effects

Seven variables characterize resource improvements; all are of the expected sign. The variables *WQ_fish*, *WQ_shell*, *WQ_many*, and *WQ_non* indicate the effects of water quality improvements associated with gains in fish, shellfish, multiple species, and unspecified habitat, respectively (see Tables A12-2 and A12-3). (One of the key advantages of the model is that it distinguishes among marginal water quality gains that influence these different types of aquatic species.) All signs are as expected. All four associated coefficients are positive and statistically significant ($p<0.05$ or better), indicating that higher WTP is associated with larger gains in water quality. This is an important result, and indicates that WTP is sensitive to the scope of water quality improvements. Moreover, the model reveals that water quality changes affecting different types of habitat (e.g., fish only, shellfish only, unspecified, or multiple species) may have substantially divergent WTP values. Given the focus of the section 316(b) rule on fish only, the ability of the model to distinguish habitat quality improvements targeted solely at fish is an important element of the model.

Another important and theoretically intuitive finding is that WTP for water quality improvements declines as baseline water quality increases. The variable *baseline* represents the baseline water quality from which water quality change would occur. The associated parameter estimate is significant ($p<0.01$) and has the expected negative sign, revealing diminishing returns to scale for water quality improvements. This finding suggests that the model is not only sensitive to scope at a broad level (i.e., larger water quality improvements generate larger WTP), but also is able to distinguish more subtle, if no less important, scope effects (WTP for marginal water quality improvements declines as baseline water quality improves).

Finally, the variable *fishplus* identifies those studies for which the associated survey identified particularly large gains in fish populations or harvest rates (>50 percent). The positive and statistically significant result ($p<0.01$) indicates that large gains in fish populations or harvests are associated with statistically significant increases in total WTP.

b. Geographic region and scale effects

Ten binary variables characterize geographic region and scale; seven are statistically significant at $p<0.10$. The default category from which these variables allow systematic variations in WTP is an estuarine waterbody in the northeast U.S.[9] Compared to this baseline, WTP associated with rivers is lower (*single_river* and *multiple_river* both have negative and significant values). *Single_lake* and *regional_fresh* both have positive values, but neither is significant. WTP for water quality gains in salt ponds (*salt_pond*) is higher than for estuaries ($p<0.05$). This is not surprising since water quality gains in salt ponds correspond to an increase in the number of acres of shellfish beds.

Of particular importance for the general validity of empirical findings, the model results further suggest that WTP is sensitive to the *number of waterbodies* under consideration. Of the waterbody categories distinguished above, both rivers and salt ponds allowed variation in numbers of affected waterbodies explicitly described by the survey. This variation is captured by the variable *num_riv_pond* (see Table A12-2).[10] The associated parameter estimate is statistically significant ($p<0.01$) and indicates that WTP increases with the number of waterbodies considered. This result, combined with the statistical

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[9] The Northeast region, as defined in Feather et al. (1999), encompasses all of the states in the National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistics Survey (MRFSS) North Atlantic region. The Northeast region also corresponds most closely to the MRFSS Mid-Atlantic region, as well as those states bordering the Great Lakes, which comprise the Great Lakes region used in this analysis.

[10] Technically, this variable is the sum of two interaction variables: 1) an interaction between *multiple_river* and the number of waterbodies noted in the survey (0 if unspecified), and 2) an interaction between *salt_pond* and the number of waterbodies noted in the survey (0 if unspecified).

significance of the water quality change variables noted above, suggests that WTP values (in this case for water quality improvements) are strongly sensitive to scope, both in terms of the number of waterbodies considered and the magnitude of water quality change.

Finally, the regional indicator variables *southeast*, *pacif_mount*, *plains*, and *mult_reg* are statistically significant at p<0.05, suggesting that there are significant differences among WTP estimates from surveys in different geographical regions of the U.S. This suggests that socio-economic and cultural factors that vary by region (but that could not be included in this model), such as education level or occupation, may affect WTP. In some cases, however, the large magnitude of these regional effects suggests that spurious or otherwise unexplained effects (e.g., the effect of specific researchers who appear more than once in the data) may drive their overall magnitude. For example, the size of the positive parameter estimate associated with WTP in the southeast U.S. leads in many cases to relatively large increases in WTP for southeast policies — a finding that defies simple intuitive explanation. Hence, EPA believes that particular, spurious, or unexplained aspects of studies from this region may have caused the associated parameter estimate to have a larger-than-expected influence on WTP.

c. Surveyed populations effects

Only two variables, *nonusers* and *income*, are used to characterize surveyed populations. In particular, the *nonusers* variable is of substantial policy relevance. The negative and strongly significant (p<.0001) parameter estimate indicates that surveys of non-users only, who by definition only have non-use values for the resource improvements in question (cf. Freeman, 2003, p. 142), generate lower WTP values than surveys that include users, who may have both use and non-use values. Based on this statistically significant result, EPA is able to use the model to estimate non-use values, interpreted as the mean WTP values estimated by surveys of non-users only (see section A12-5). Such methods, however, may underestimate non-use values of the general population, if the non-use values of users exceed those of non-users (Whitehead and Blomquist, 1991b).

The *income* parameter estimate is positive, as expected, but is not statistically significant.

d. Study and methodology effects

A variety of study and methodology effects can be shown to influence WTP for water quality improvements. While not surprising, this does indicate that the methodological approach influences WTP, as argued by Arrow et al. (1993). Of 12 variables characterizing study and methodological effects, 10 are statistically significant at p<0.10. Among these is the year in which a study was conducted (*year_indx*, a continuous variable), with later studies associated with lower WTP. This is the expected result, as the focus of survey design over time has often been on the reduction of survey biases that would otherwise result in an overstatement of WTP (Arrow et al., 1993).

Model results reveal that voluntary (*voluntary*=1) payment vehicles (i.e., surveys that describe hypothetical payments as voluntary) are associated with reduced WTP estimates. This result counters common intuition and empirical findings that voluntary payment vehicles are associated with overstatements of true WTP (Carson et al., 2000). The reason for this counter-intuitive finding is unknown, but may be a feature of the small number of studies that applied voluntary mechanisms. Reduced WTP estimates are also associated with studies applying nonparametric methods to WTP estimation (*nonparam*). Survey elicitation method does not have a strong effect in this model; studies using discrete choice formats have higher WTP values, but this difference is not statistically significant.

Smaller WTP estimates are associated with studies that eliminate or trim outlier bids when estimating WTP (*outlier_bids*=1; p<0.01). However, increased WTP estimates are associated with studies that seek to eliminate protest bids (*protest_bids*=1; p<0.01). While one might assume that elimination of protest bids would reduce WTP, this is based on a perhaps mistaken presumption that only high protest bids are excluded. In many cases WTP estimates may also exclude protest "zeros," or zero bids. As a result, there is no *a priori* necessary expected sign for this effect. Studies that report median WTP (*median_WTP*) have higher WTP values, but this effect is not statistically significant. Nonetheless, this variable is retained for theoretical reasons.

Studies with high response rates (*hi_response*=1; p<0.01) are associated with lower WTP estimates — an expected result. In addition, lower WTP is associated with the use of the RFF water quality ladder in the original survey (*wq_ladder*=1; p<0.10). As is the case with a variety of study design variables, there is no *necessary* expectation with respect to the direction of this effect. Nonetheless, this finding might suggest the capacity of such scales to clarify the specific magnitude and implications of water quality change, and hence (perhaps) reduce methodological misspecification or symbolic biases that might act to systematically inflate estimated WTP.

Survey format variables also have an effect on WTP, as might be expected. *Interview* and *mail* both have positive and statistically significant coefficients ($p<0.01$), compared to the default of telephone surveys. It may be possible that the interview survey format results in larger WTP values either because the respondents are better able to understand the valuation scenario, or because respondents may feel pressure from interviewers to bias their WTP estimates upward. There is no *a priori* explanation for the difference between mail surveys and phone surveys. Finally, as expected, studies that ask respondents to report an annual payment (as opposed to a *lump_sum* payment) have lower WTP estimates ($p<0.05$).

e. Model limitations

The validity and reliability of benefit transfer — including that based on meta-analysis — depends on a variety of factors. While benefit transfer can provide valid measures of use and non-use benefits, tests of its performance have provided mixed results (e.g., Desvousges et al., 1998; Vandenberg et al., 2001; Smith et al., 2002). Nonetheless, benefit transfers are increasingly applied as a core component of benefit cost analyses conducted by EPA and other government agencies (Bergstrom and De Civita, 1999; Griffiths, *undated*). Moreover, Smith et al. (2002, p. 134) argue that “nearly all benefit cost analyses rely on benefit transfers, whether they acknowledge it or not.” Given the increasing [or as Smith et al. (2002) might argue, universal] use of benefit transfers, an increasing focus is on the empirical properties of applied transfer methods and models.

Although the statistical performance of the model is quite good, EPA notes several limitations of the model. These limitations stem largely from information available from the original studies, as well as degrees of freedom and statistical significance. An important factor in any benefit transfer is the ability of the study site or estimated valuation equation to approximate the resource and context under which benefit estimates are desired. As is common, the meta-analysis model presented here provides a close but not perfect match to the context in which values are desired. Specifically, the model estimates WTP for marginal improvements to aquatic habitat that directly benefit fish populations. The specification of the model distinguishes improvements that benefit only fish populations from those that benefit other aquatic or non-aquatic species (as stated in the original surveys whose WTP estimates are incorporated in the meta-analysis). The model also distinguishes effects related to surveys emphasizing non-fishing uses of affected waterbodies. However, the original studies in the meta-analysis do not (in general) value individual fish. Hence, additional assumptions are required to estimate non-use values; these are discussed in section A12-5.

Additional limitations relate to the paucity of demographic variables available for inclusion in the model. The only demographic variable incorporated in the analysis (*income*) was not statistically significant. Moreover, other demographic variables are unavailable. EPA recognizes that the model is statistically significant and allows estimation of WTP from study and site characteristics. However, strictly speaking, model findings are relative to the specific case studies considered, and must be viewed within the context of 78-observation data set, with all the appropriate caveats. Although this represents a fairly standard-to-large sample-size for a meta-analysis in this context, it is relatively small relative to other statistical applications in resource and environmental economics. Model results are also subject to choices regarding functional form and statistical approach, although many of the primary model effects are robust to reasonable changes in functional form and/or statistical methods. The rationale for the specific functional form chosen here (the semi-log form) is detailed above.

Finally, the relatively large (positive) magnitude of the parameter estimate for the southeastern U.S. regional dummy variable (*southeast*) leads EPA to question the appropriate interpretation of this effect. While it is theoretically possible that WTP for water quality changes is substantially higher in the southeast, the magnitude of the effect suggested by the model seems unlikely from an intuitive perspective. As suggested above, it is possible that spurious, unexplained factors influence the magnitude of this parameter in the present model. However, assessments of preliminary model runs suggest that this effect is relatively robust given the present data and selection of variables available. Nonetheless, EPA recommends that the magnitude of the predicted shift in WTP associated with the southeast region should be viewed with caution.

Based on the results presented in Table A12-3, EPA estimated WTP for water resource changes as a function of resource, regional, and study design attributes (see section A12-5). This, in general, provides a superior alternative to the calculation and use of a simple arithmetic mean over the 78 observations, as it allows WTP to be adjusted to account for the characteristics of the transfer site. The ability of the model to appropriately adjust WTP is suggested by the many systematic (statistically significant) patterns revealed by the meta-analysis regression model. Nonetheless, the use (and interpretation) of such WTP estimates for benefit transfer is subject to the constraints and concerns expressed elsewhere in the literature (e.g., Vandenberg et al., 2001; Desvousges et al., 1998; Poe et al., 2001).

A12-4 Log-Log Meta-Analysis Regression Model

The following sections present the results for the alternative log-log meta-analysis regression model. Section A12-4.1 presents the data and variable specifications used to estimate the log-log model; section A12-4.2 presents the results of the log-log model; and section A12-4.3 discusses and interprets the findings of the log-log model.

A12-4.1 Meta-Data for Log-Log Model (Alternative Specification)

The dependent variable in the log-log meta-analysis is the natural log of estimated WTP (2002$) for water quality improvements as reported in each original study. Right-hand-side continuous and categorical variables relate to study and methodology, population, spatial, and water quality characteristics.

Study and methodology variables characterize such features as:

- The year in which the study was conducted. For this model, a binary variable that identifies those studies conducted in 1990 or before was employed. A continuous variable for the study year would be problematic for the log-log form. EPA selected 1990 for the break in light of the increased attention to stated preference methods following the Exxon Valdez disaster.
- Whether a discrete choice model was used.
- The survey mode of administration (telephone surveys are the default category).
- Whether the payment vehicle was voluntary.
- Whether WTP was expressed in terms of something other than an annual payment, such as a lump sum or a series of installments.
- Whether the WTP was estimated using a parametric model.
- Whether protest or outlier bids were discarded before WTP was estimated.

Surveyed population variables characterize such features as:

- Mean income of respondents.
- Whether the sample or sub-sample consisted of users, non-users, or a general population that included both. These appear in the model as interactions with the water quality change variable.
- Whether the sample included non-local respondents, such as might occur using an intercept survey.

Spatial variables characterize such features as:

- The waterbody type and scale. The default category reflects large saltwater bodies.
- Region of the country. The Northeast is the default region.
- Whether the aquatic resource is known primary as a Superfund site on the National Priority List. This variable is intended to single out and control for one particular study (Schulze et al., 1995).

Water quality variables characterize such features as:

- Whether the change scenario focused on wildlife, on fish specifically, or on a broader set of attributes (that may have included recreational opportunities or aesthetic qualities). Those that are more general compose the default category.
- The desired level of water quality. This performs a function analogous to incorporating the baseline water quality level into the model but avoid issues associated with taking the natural log of 0.
- The extent of water quality change.

Eighty-two observations from 33 studies were used to estimate the model. Variables incorporated in the final model are listed and described in Table A12-4.

Table A12-4: Meta-Analysis Variables and Descriptive Statistics for the Log-Log Model

Variable	Description	Units and Measurement	Mean (Std. Dev.)
ln_wtp	Natural log of WTP for specified resource improvements.	Natural log of dollars	4.55 (0.80)
year1990	Binary (dummy) variable indicating that the year of the study was 1990 or earlier.	Binary	0.66
discrete_ch	Binary (dummy) variable indicating that WTP was estimated using a discrete choice survey instrument.	Binary	0.33
interview	Binary (dummy) variable indicating that the survey used an interview mode of administration.	Binary	0.24
mail	Binary (dummy) variable indicating that the survey used an mail-in mode of administration.	Binary	0.54
voluntary	Binary (dummy) variable indicating that WTP was estimated using a payment vehicle described as voluntary.	Binary	0.16
lump_sum	Binary (dummy) variable indicating that payment was to occur on something other than an annual basis.	Binary	0.20
nonparam	Binary (dummy) variable indicating that WTP was estimated using nonparametric methods.	Binary	0.46
protest_bids	Binary (dummy) variable indicating that protest bids were excluded when estimating WTP.	Binary	0.44
outlier_bids	Binary (dummy) variable indicating that outlier bids were excluded when estimating WTP.	Binary	0.24
ln_income	Natural log of the mean income of survey respondents.	Natural log of thousands of dollars	3.82 (0.20)
nonusers	Binary (dummy) variable indicating that the WTP estimate is based upon a sample of non-users.	Binary	0.17
users	Binary (dummy) variable indicating that the WTP estimate is based upon a sample of users.	Binary	0.26
genpop	Binary (dummy) variable indicating that the WTP estimate is based upon a sample of a general population consisting of both users and non-users.	Binary	0.57
nonlocal	Binary (dummy) variable indicating that the WTP estimate is based upon a sample not limited to locals.	Binary	0.46
small_rivers	Binary (dummy) variable indicating that the water quality change affects river resources of a small region, e.g., the Potomac River in DC.	Binary	0.18
large_rivers	Binary (dummy) variable indicating that the water quality change affects river resources of a large region, e.g., the Columbia River Basin.	Binary	0.21
small_lakes	Binary (dummy) variable indicating that the water quality change affects lake resources of a small region, e.g., Clear Lake, IO.	Binary	0.12
large_lakes	Binary (dummy) variable indicating that the water quality change affects lake resources of a large region, e.g., Lake Michigan.	Binary	0.05
small_fresh	Binary (dummy) variable indicating that the water quality change affects fresh water resources — either unspecified or a combination of types — of a small region.	Binary	0.09
large_fresh	Binary (dummy) variable indicating that the water quality change affects fresh water resources — either unspecified or a combination of types — of a large region, e.g., lake and streams of northeastern MN.	Binary	0.11
natl_fresh	Binary (dummy) variable indicating that the water quality change affects fresh water resources nationwide.	Binary	0.06
small_salt	Binary (dummy) variable indicating that the water quality change affects saltwater resources in a limited area.	Binary	0.07

Table A12-4: Meta-Analysis Variables and Descriptive Statistics for the Log-Log Model			
Variable	**Description**	**Units and Measurement**	**Mean (Std. Dev.)**
great_lakes	Binary (dummy) variable indicating that survey was conducted in the Great Lakes region.	Binary	0.37
pacif_mount	Binary (dummy) variable indicating that survey was conducted in the Pacific/mountain region.	Binary	0.18
plains	Binary (dummy) variable indicating that survey was conducted in the Plains region.	Binary	0.09
southeast	Binary (dummy) variable indicating that survey was conducted in the Southeast region.	Binary	013
multi_reg	Binary (dummy) variable indicating that survey was conducted in multiple regions.	Binary	0.09
npl	Binary (dummy) variable indicating that the aquatic resource is known primarily as a Superfund site.	Binary	0.02
wildlife	Binary (dummy) variable indicating that the changes valued relate expressly to wildlife populations.	Binary	0.05
fish_only	Binary (dummy) variable indicating that the changes valued relate expressly to fish populations.	Binary	0.15
ln_hiwq	Natural log of desired water quality level expressed on a 0-100 scale.	Natural log of desired water quality level	4.30 (0.35)
ln_chwq	Natural log of water quality change expressed on a 0-100 scale.	Natural log of water quality change	3.77 (0.38)

Source: U.S. EPA analysis, for this report.

A12-4.2 Log-Log Model and Results

a. Log-log model

In light of the absence of a standard approach to developing parametric models to synthesize valuation summary results, there is good reason to explore and report on an alternative to the semi-log model that makes different, though plausible, assumptions for a few critical aspects of the meta-analysis. Although the two models share many features (e.g., their consideration of random effects), the alternative model developed by EPA departs from the former in three significant ways:

❖ ***Functional form***

The first significant difference between the two models is that the alternative model takes a log-log form, i.e., the natural log of both the dependent variable and all covariates are taken. This functional form makes sense on three counts. First, study features and resource characteristics likely affect WTP in a multiplicative, rather than additive, fashion. With the log-log form, this is how explanatory variables affect the underlying (un-logged) dependent variable. Second, this functional form has the desirable feature of associating a WTP of $0 with any scenario in which no water quality change has occurred. Third, by forcing the curve through the origin, the model increases sensitivity of the WTP estimates to the magnitude of the water quality change, i.e., scope.

❖ ***Water quality change index***

The second difference between the two models is that the alternative model uses a different approach to mapping the somewhat disparate scenarios valued by respondents in the original studies onto a water quality metric. For the alternative model, EPA first established what the upper and lower bounds of water quality were for each study, i.e., how the researcher explicitly or implicitly defined the level at which the waterbody was “dead” or totally impaired and that at which it was considered pristine. These points of reference were used to define the endpoints on a scale of 0 to 100. With the endpoints established, the Agency mapped the baseline water quality levels and the magnitude of the water quality change onto this new ratio scale.

The way that EPA mapped water quality changes onto the meta model's index depended on how they were characterized in the original studies:

- For water quality changes specified by a study as movements along a generic ordinal scale (e.g., poor, fair, good, excellent), the original levels were positioned at uniform intervals across the new index (e.g., 0, 33, 67, 100) and changes calculated as the difference between the two relevant values.

- For water quality changes that refer to levels at which particular recreation types are possible (e.g., non-boatable, boatable, fishable, swimmable), the original levels were placed on the index at the same relative position in which they would be found on the "RFF water quality ladder" (e.g., 0, 2.5, 5, 7), which some studies handed to respondents during interviews.

- For water quality changes expressed in terms of species' populations (e.g., 25 percent increase in trout populations), the baseline value on the index was selected according to whatever narrative or quantitative information was provided in the original survey or study, and considering that 0 would equate to extirpation of the species and 100 to historic, peak population levels. The change upon which a valuation scenario was based was then applied to this baseline index value. For example, a 25 percent increase in a trout population described as currently being in fair condition would be translated into a 25 percent shift in the index from 33 to 42.

❖ ***Focusing on non-use value for changes in fish populations***

The third difference between the two models is that the alternative model includes the sample type dummies as interactions with *ln_chwq*, allowing the relationship between WTP and water quality change to vary according to the degree to which use values are reflected in WTP responses. While consideration was given to further interacting *ln_chwq* with the species focus dummies, the lack of observations in some of the cross-categories effectively precluded it.

The log-log meta model facilitates policy simulations. For example, estimating the WTP for the non-use value of the section 316(b) rule effects would require a focus both on a water quality change that affects solely fish and on non-use values. Use of the model for this purpose is straightforward, essentially involving assigning a value of 1 to both *fish_only* and *nonusers*, the latter of which is interacted with the appropriate water quality change measured on the index as well as its ln_chwq parameter.

b. Log-log model results

Table A12-5 presents results of the log-log model.

Table A12-5: Estimated Multilevel Model Results for the Log-Log Model: WTP for Aquatic Habitat Improvements

Variable	Parameter Estimate	Robust Std. Error	t Statistic	Prob>|t
intercept	6.64	1.57	4.23	0.00
year1990	0.89	0.21	4.19	0.00
discrete_ch	0.69	0.25	2.72	0.01
interview	0.50	0.16	3.07	0.00
mail	0.11	0.26	0.41	0.68
voluntary	0.55	0.21	2.71	0.01
lump_sum	0.82	0.27	3.00	0.00
nonparam	-0.38	0.18	-2.10	0.04
protest_bids	1.00	0.15	6.88	0.00
outlier_bids	-0.23	0.10	-2.27	0.03
ln_inc	-1.32	0.31	-4.29	0.00
nonlocal	-0.63	0.29	-2.20	0.03
small_river	-1.78	0.61	-2.94	0.01
large_river	-0.37	0.33	-1.13	0.27
small_lake	0.13	0.25	0.53	0.60

Table A12-5: Estimated Multilevel Model Results for the Log-Log Model: WTP for Aquatic Habitat Improvements

Variable	Parameter Estimate	Robust Std. Error	t Statistic	Prob>|t
large_lake	1.56	0.46	3.40	0.00
small_fresh	0.27	0.16	1.68	0.10
large_fresh	0.78	0.31	2.50	0.02
natl_fresh	0.99	0.42	2.34	0.02
small_salt	2.79	0.33	8.39	0.00
great_lakes	-0.50	0.56	-0.90	0.38
pacif_mount	-1.28	0.28	-4.52	0.00
plains	-0.38	0.23	-1.70	0.10
southeast	-3.01	0.68	-4.44	0.00
multi_reg	-0.50	0.22	-2.28	0.03
npl	-1.09	0.22	-4.93	0.00
wildlife	-0.32	0.25	-1.26	0.22
fish_only	-0.48	0.23	-2.04	0.05
ln_hiwq	-0.07	0.33	-0.22	0.83
*ln_chwq*nonusers*	0.66	0.31	2.12	0.04
*ln_chwq*users*	0.82	0.31	2.63	0.01
*ln_chwq*genpop*	0.70	0.28	2.48	0.02
-2 Restricted Log Likelihood	118.0			
Covariance Factors				
Study Level (σ_u)	0.12			
Residual (σ_e)	0.21			
χ^2 for significance of random-effects	0.00			

Source: U.S. EPA analysis, for this report.

A12-4.3 Interpretation of Log-Log Regression Analysis Results

The log-log model finds both statistically significant and economically reasonable patterns influencing WTP for water quality improvements. The statistical fit of the equation is good; there is a strong systematic element of WTP variation which allows forecasting of WTP based on site and study characteristics. The model as a whole is statistically significant at better than p<0.0001.

While author-level random-effects are not statistically significant (2 of 0), 25 of the 31 fixed-effects (disregarding the intercept) in the model are significant at p<0.1. Nearly all of the signs of the significant parameter estimates correspond with prior expectations.

a. Resource improvement effects

EPA included two dummy variables in the log-log model, *wildlife* and *fish_only*, that measured the species that were affected by the water quality change. The negative signs on these parameter estimates support the expectation that respondents provide a lower WTP for water quality improvements described solely in terms of changes in species populations. Further, a description that is limited to effects on fish relates to a lower WTP than one depicting effects on other wildlife as well, e.g., fish-eating birds.

The model included several water quality variables. The positive and statistically significant ($p<0.05$) estimates for the three *ln_chwq* interaction terms support the hypothesis that higher WTP values are associated with larger water quality changes. Moreover, the relative sizes of the estimates provide support to prior expectations in that the non-user value is smallest and the user value largest. The statistically insignificant estimate for *ln_hiwq* suggests that the level of water quality has little effect on the WTP for the change in water quality, i.e., there may not be a big difference in the respondent's mind between an improvement that raises water quality from a poor to a mediocre state and one that raises it to a mediocre to an excellent state as long as the changes are thought to be of the same magnitude.

b. Geographic region and scale effects

Most of waterbody scale and type dummies have parameter estimates that are statistically significant at $p<0.1$. For the most part, the estimates for the "large" dummies are larger than the "small" ones, which would be expected. Surprisingly, the estimates for *small_lake* and *large_lake* are both significant and relate to each other in the opposite manner. This may be due to that these two categories may differ in kind more than degree, as Great Lakes studies exert a strong influence in the latter. The negative and statistically significant ($p<0.01$) estimate for *npl* indicates that waterbodies that are recognized Superfund sites may be considered by respondents to be qualitatively different, and of lesser value, than other waterbodies.

Although there are no prior expectations for the regional dummies, all estimates are significant at $p<0.1$. The results suggest that the default region, the North Atlantic, has higher WTP values than elsewhere, whereas the Inland region has the lowest.

c. Surveyed population effects

The negative and statistically significant ($p<0.01$) estimate for *ln_inc* indicates that lower incomes are associated with relatively higher WTP estimates. This does not correspond well with the commonly held notion of environmental quality as luxury good. However, since *ln_inc* is the only variable in the model that relates to respondent socioeconomic characteristics, it is possible that it is picking up the influence of omitted factors, such as demographics (e.g., retirees may appreciate aquatic resources more) or locale (e.g., rural respondents may as well).

The negative and statistically significant ($p<0.05$) estimate for *nonlocal* supports the hypothesis that respondents who live further from a resource do not value it as highly.

d. Study and methodology effects

There are no strong theoretical expectations about the sign or magnitude of several of the study and methodology variables. The results from the log-log model show positive and statistically significant ($p<0.01$) parameter estimates for *discrete_ch*, *interview*, *voluntary*, and *lump_sum*. These results indicate that the discrete choice study type, the interview solicitation method, the voluntary payment mechanism, and the lump sum payment type are all associated with higher WTP values.

The signs of the remaining variables generally correspond with prior expectations. The statistically significant estimates for *nonparam* (negative, $p<0.05$), *protest_bids* (positive, $p<0.01$), and *outlier_bids* (negative, $p<0.05$) indicate that studies that use a parametric model, exclude protest bids, or include outlier bids have relatively higher WTP values. The positive and statistically significant ($p<0.01$) estimate for *year1990* supports the hypothesis that earlier surveying and modeling approaches may have biased WTP estimates upward.

A12-5 Application of the Meta-Analysis Results to the Analysis of Non-Use Benefits of the Section 316(b) Rule

The results of the meta-analysis in conjunction with information specific to the affected aquatic resources and the populations that will benefit from reduced I&E impacts can be used to estimate the non-use value of the section 316(b) regulation. This analysis involves the following steps:

- Estimating annual non-use value of the affected fishery resources per household for completely eliminating baseline I&E losses, and for reducing I&E losses from the baseline to post-compliance levels;
- Estimating the population of households holding non-use value for the affected resources; and
- Estimating the total non-use value to the affected populations for completely eliminating baseline I&E losses, and for reducing I&E losses from the baseline to post-compliance levels.

A12-5.1 Estimating Non-Use Values per Household

Region-specific non-use WTP values for aquatic habitat improvements can be estimated for two population classes: (1) all households in the vicinity of the waterbodies affected by I&E, and (2) recreational anglers who may visit the affected waterbody. Separate household values can be estimated using the semi-log and log-log regression equations specified in sections A12-3.2 and A12-4.2, respectively. To estimate the non-use values of baseline I&E losses and reduced I&E impacts, values should be assigned to independent variables to reflect resource characteristics, area demographics, and other factors. These values are then multiplied by the estimated regression coefficients to predict the average non-use WTP for aquatic habitat improvements for a household with specific characteristics (e.g., non-user household in the North Atlantic region).

Two variables are of particular importance to the valuation of benefits of the final section 316(b) rule: *baseline* and *WQ_fish*. For example, it can be assumed that all waterbodies affected by cooling water intakes meet water quality standards (*baseline*=7.0 or swimmable conditions). In reality, some waterbodies may not meet water quality standards. EPA notes that this assumption leads to more conservative estimates of non-use values for aquatic habitat improvements, because higher baseline quality leads to lower WTP for environmental improvements. If feasible, site specific values should be used for the *baseline* variable.

The *WQ_fish* variable, the effect of aquatic habitat quality change on fish, is a key policy variable. The value assignments of the *WQ_fish* variable should be based on the expected change in recreational fishing quality at the affected sites, which is measured by the expected change in recreational catch rate. For example, the estimated changes in recreational catch rates from eliminating baseline I&E losses range from 2.5 percent to 25.9 percent, with a mean value of 12.9 percent. The estimated changes in recreational catch rates under the final option range from 1.2 percent to 12.6 percent, with a mean value of 6.3 percent.

Using the equation specified in the preceding section and the values of independent variables described above, one can derive region-specific WTP values for all households in the vicinity of the waterbodies affected by I&E losses.

A12-5.2 Estimating the Affected Populations

Two non-use benefit population categories should be considered in this analysis: 1) households in the counties abutting the affected waterbodies, and 2) recreational anglers residing outside of the abutting counties but who visit recreational fishing sites in each study region. Households in the counties abutting the affected waterbodies can be further restricted to include only households in counties where some part of the county is within 10 miles of a power plant subject to the Phase II section 316(b) rule.[11] The sum of the two affected household categories for a given study region, assuming one user household per recreational angler, represents the total population of households affected by I&E impacts at section 316(b) facilities.[12] The following data sources can be used to obtain information on the number of anglers visiting recreational fishing sites in a given region:

- Coastal region — National Marine Fisheries Statistics Survey (NMFS, 1997-2001); and
- Great Lakes region — 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Fish and Wildlife Service, 2001).

U.S. Census Bureau data can be used to estimate the number of households residing in the counties abutting the affected waterbodies (U.S. Census Bureau, 2002).

EPA notes that resource users typically hold higher non-use values than the non-use values held by non-users for the same resource, and therefore the application of total *non-user* value, which is used in this analysis to approximate total *non-use* value, may underestimate the total non-use value of aquatic habitat improvements. In addition, the two population categories considered in the non-use benefits analysis do not represent all the households that may hold values for these natural resources (e.g., households in coastal states outside of the counties abutting the affected waterbodies). Furthermore, most of the studies on which the meta-analysis was based analyzed sample populations from larger geographic areas than the area considered

[11] This 10 mile criterion is a conservative assumption that excludes households in counties that abut large, affected waterbodies, but that are distant from section 316(b) facilities.

[12] The relevant population in this analysis is the number of households because WTP for environmental improvements are estimated on per-household basis.

here. For these reasons, the resulting non-use estimates are likely to represent a lower-bound estimate of the value of reduced baseline I&E losses.

A12-5.3 Estimating the Total Non-Use Value to the Affected Populations

Total regional non-use value can be calculated by multiplying the region-specific non-use value per household from each regression model by the corresponding estimate of the total number of affected households in each region.

A12-6 Limitation and Uncertainties

A number of issues are common to all benefit transfers. Benefit transfer involves adapting research conducted for another purpose in the available literature to address the policy questions at hand. Because benefits analysis of environmental regulations rarely affords enough time to develop original stated preference surveys that are specific to the policy effects, benefit transfer is often the only option to inform a policy decision. Specific issues associated with the estimated regression model and the underlying studies are discussed in discussed in section A12-3.3e. Additional limitations and uncertainties associated with implementation of the meta-analysis approach are addressed below.

A12-6.1 Sensitivity Analysis of Semi-Log Model Based on Krinsky and Robb (1986) Approach

The semi-log model presented above can be used to predict WTP for each of the studies in the database; however, estimates derived from regression models are subject to some degree of error and uncertainty. To better characterize the uncertainty or error bounds around predicted WTP, EPA recommends using the procedure described by Krinsky and Robb in their 1986 *Review of Economics and Statistics* paper "On Approximating the Statistical Property of Elasticities." The procedure involves sampling the variance-covariance matrix of the estimated coefficients, which is standard output from the statistical package used to estimate the meta model. WTP values are then calculated for each drawing from the variance covariance matrix and an empirical distribution of WTP values is constructed. By varying the number of drawings, it is possible to generate an empirical distribution with a desired degree of accuracy (Krinsky and Robb, 1986). The lower or upper bound of WTP values is then identified based on the 10^{th} and 90^{th} percentile of WTP values from the empirical distribution. These bounds may help decision-makers understand the uncertainty associated with the benefit results.

A12-6.2 Sensitivity Analysis of Variable Assignments for Independent Regressors

In addition to developing the WTP values and bounds based on best estimates of values for independent variables, EPA recommends performing a sensitivity analysis to show how these values could change based on more site-specific or geographic-specific conditions and alternative assumptions regarding desirable study characteristics.

A12-6.3 Affected Population

As noted above, the two population categories considered in the non-use benefits analysis do not represent all the households that may hold values for these natural resources (e.g., households in coastal states outside of the counties abutting the affected waterbodies). The resulting non-use estimates therefore are likely to represent a lower-bound valuation of reduction in baseline I&E losses. However, EPA notes that some resource valuation studies have found that respondents in the typical contingent market situation may overstate their WTP compared to their likely behavior in a real world situation. EPA recommends conducting a sensitivity analysis to assess the effect of hypothetical bias on the estimated non-use values. For example, one can assume that only 50 percent of the households residing in the vicinity of the affected waterbodies would actually pay for aquatic habitat improvements resulting from reduced I&E.