CONDUCTING BENEFIT TRANSFERS — CHAPTER 4

EPA analysts often use the benefit transfer technique to value the benefits of drinking water and other regulations. This technique involves using estimates from existing research (based on the methods described in Chapter 3) to value the benefits of the regulatory options under consideration.[1] Existing studies usually assess effects that differ in some respects from the effects of a particular regulation. Analysts thus review the applicability, as well as the quality, of the available studies to determine whether and how to apply them to a specific regulatory scenario. EPA analysts frequently use benefit transfer techniques when estimating the value of effects on human health and the environment, and may also apply this approach when assessing effects on aesthetic properties or material damages.[2]

Benefit transfer is considered a "secondary" methodology because it does not involve collecting primary valuation data. Rather, benefit transfer is a process for reviewing and adjusting existing data to arrive at valuation estimates for the subject under consideration. The study that is the source of existing data is typically called the "study case" and the subject under consideration is called the "policy case." The main advantage of benefit transfer is that the process is less expensive and time consuming than primary valuation techniques. Thus, benefit transfer is useful when limited time and resources preclude conducting primary research to inform policy decisions. It can also be used as part of a preliminary or screening analysis to determine whether additional primary research is warranted and to inform the early phases of the regulatory development process.

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[1] For general information on benefit transfer techniques, see: U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses,* EPA 240-R-00-003, September 2000. *Water Resources Research*, Vol. 28, No. 3, 1992 (an entire issue devoted to benefit transfer); and Desvousges, William H., et al., *Environmental Policy Analysis with Limited Information: Principles and Applications of the Transfer Method,* Edward Elgar Publishing: Northampton, Massachusetts, 1998.

[2] The use of benefit transfer for policies affecting human health is discussed in: U.S. Environmental Protection Agency, *Handbook for Noncancer Health Effects Valuation (draft)*, prepared by Industrial Economics, Incorporated, September 1999. Additional information will be available in EPA's forthcoming *Children's Health Valuation Handbook.* The use of these techniques for natural resource damage assessment is described in: Industrial Economics, Incorporated, *Economic Analysis for Hydropower Project Relicensing: Guidance and Alternative Methods*, prepared for U.S. Fish and Wildlife Service, October 1998.

The overall quality of a benefit transfer relies heavily on the good judgement of the analyst; this chapter describes "best practices" for this type of analysis. Benefit transfer is likely to yield estimates that are less accurate than those that would result from a carefully designed and implemented primary valuation study that directly addresses the effects of concern. Hence the analyst generally presents the implications of the assumptions and uncertainties in the transfer along with the analytic results, so that policymakers can take these implications into account when making regulatory decisions.

This chapter first describes the steps for implementing benefit transfers. Next, it provides a worksheet that analysts can use when assessing the quality, applicability, and transferability of existing studies. Finally, the chapter concludes with a fictional case study that illustrates the benefit transfer technique.

4.1 Implementation Steps

Benefit transfer consists of five steps:

- **Step 1: Describe the Policy Case.** Describe in detail the health or other effects relevant to the proposed regulation, the impacts of these effects, and the demographic characteristics of the affected population.

- **Step 2: Identify Existing Relevant Studies.** Search the economics valuation literature for studies that address similar types of effects.

- **Step 3: Review Existing Studies for Quality and Applicability.** Assess the quality of the identified studies by determining whether they follow generally accepted best practices for the methods used. Assess applicability in terms of: (1) the similarity of the effects; (2) the similarity of the populations experiencing the effects; and (3) the ability to adjust for differences between the study scenario and the policy scenario.

- **Step 4: Transfer the Benefit Estimates.** Conduct the transfer, making any necessary adjustments to existing estimates and applying them to the policy scenario. The transfer may be based on the results of a single study or of several studies.

- **Step 5: Address Uncertainty.** Address uncertainties in the estimates, for example by conducting sensitivity or other types of analysis as appropriate.[3]

[3] The economics profession sometimes uses the term "uncertainty" to refer to situations where probabilities are unknowable and "risk" where probabilities are known. In this document, we use the more general definition of uncertainty as "lack of knowledge."

Each of these steps is discussed in more detail in the following sections.

4.1.1 Step 1: Describe the Policy Case

To conduct a benefit transfer, the analyst first constructs a detailed description of the contaminant and each effect of concern; i.e., each particular type of health or other effect likely to be reduced by the regulatory options. As discussed in Chapter 1 of this document, regulations establishing Maximum Contaminant Levels (MCLs) or treatment techniques for drinking water generally provide human health benefits, reducing mortality and morbidity from various illnesses. EPA generally uses benefit transfer to value fatal risks, combining the results of several wage-risk and contingent valuation studies as discussed previously in Chapter 3. For non-fatal health effects, estimates of willingness to pay to avoid related risks are available for relatively few effects of concern. Hence, analysts often transfer values from a study of one health effect (the study case) to determine the value of a similar health effect resulting from a particular regulation (the policy case).[4]

Drinking water regulations also may decrease ecological risks (e.g., if they encourage increased source water protection), reduce materials damages (e.g., corrosion of piping and equipment), and provide aesthetic benefits (e.g., improved clarity, taste or odor of drinking water). Benefits transfer may also be useful in assessing some of these other types of effects.

Health Effects

Policy analysts generally rely on health scientists, engineers, and other experts to provide information on the effects of the contaminant. The role of the analyst is to ensure that he or she develops a full understanding of each effect to be assessed, including any uncertainties in its description. This detailed description includes:

- The *physical symptoms* associated with the health effect. For example, for kidney disease, the analyst would describe in detail conditions such as impaired mobility, muscle cramps, hypertension and infections, as well as associated lifestyle changes and emotional stresses. Emotional stresses could include effects such as depression or anxiety related to symptoms, prognosis, or other aspects of the illness. The severity of the effects and the extent to which the symptoms curtail normal activities are also considered, as well as information on the fatality rates.

[4] These transferred estimates of willingness to pay may be presented along with cost-of-illness estimates. Cost-of-illness values are often available for the effect of concern and can be interpreted as providing a likely lower bound estimate of willingness to pay, as discussed in Chapter 3 of this document.

- The *timing and duration* of the effect. An effect may occur immediately upon exposure, or there may be a significant delay between exposure and manifestation of a health effect (i.e., latency). Also there may be a lag (cessation lag) between the cessation or reduction of exposure and a reduction of risk. The health effect may be a short-lived (acute) or a long-term (chronic) condition.

- The *population affected*. Exposure to a contaminant may be more or less likely to lead to adverse effects depending on factors such as age and current health status. The description of the population most likely to be affected by the disease includes the factors that lead to heightened vulnerability such as lifestyle issues (e.g., smoking) or pre-existing conditions (e.g., depressed immune system). It also addresses factors that may affect willingness to pay, such as demographic or socio-economic characteristics including age, sex, geographic location, income level, or race. Analysts also describe the extent to which the health effect is likely to be prevalent, that is, likely to occur in most persons exposed to the contaminant or only in a fraction of the exposed population.

This information is accompanied by a description of the key uncertainties in the health science data related to each of these factors. Uncertainties could, for example, include a lack of knowledge about the physiology of the effect, the emotional stresses of the effect, the risk factors that make individuals or populations susceptible to the effect, or the prevalence of the effect. In addition, uncertainties related to the causative link between a drinking water contaminant and a particular health effect may be significant. It is not unusual to find that uncertainties in the risk assessment far outweigh uncertainties in other aspects of the benefit-cost analysis.

Ecological Effects

Benefit transfer is often used to value ecological effects, for which the literature includes numerous willingness to pay studies. Such a transfer may involve the application of estimates from a studied site to other sites experiencing similar effects, or the combination of values from several studies to estimate the value of such effects in other cases. When combining values for different aspects of an effect from several studies, the analyst is careful to avoid double counting. For example, the value of wildlife viewing may be related to the value of surrounding properties, and analysts attempt to address the overlap (in quantitative or qualitative terms) if both types of benefits are considered.

The starting point for transferring these types of values is to describe the ecological effects addressed by regulatory standards. The description details the natural resources affected, their current (baseline) condition, and the characteristics and severity of the effects reduced. In addition, the services provided by the resource (such as recreational activities, commercial use, or wildlife viewing) are discussed.

The description considers the timing and duration of the effects as well as the potential for natural recovery. The analyst also addresses the characteristics of the human population (for example, recreational anglers, local residents) who may benefit from the ecological improvement. This description guides the subsequent economic analysis, and addresses the characteristics of the ecological effect likely to affect willingness to pay.

Materials and Aesthetic Qualities

In cases where a regulation reduces damages to materials or improves the aesthetic qualities of drinking water, benefit transfer may also be used. For example, a few analyses of averting behavior or avoided costs are available in the literature that could be used to value certain of these types of effects. In such cases, the analyst again begins the transfer process by describing the effect of concern and baseline conditions in detail, including the characteristics and timing of the reduced effect and the population or water systems affected. In some cases, the regulations may alleviate, but not eliminate, adverse impacts, and this concern will need to be taken into account. For example, regulation of a particular contaminant may reduce or delay, but not eliminate, pipe corrosion, or may only partially mitigate taste or odor problems.

4.1.2 Step 2: Identify Existing Relevant Studies

Once the analyst completes the description of the policy case, the next step is to conduct a comprehensive literature search to identify existing valuation literature that focuses on similar effects. The analyst explores journal articles, research reports, dissertations, and published texts identified through a review of databases of environmental, economic, and medical literature, as relevant. There are several bibliographic databases available through Internet services such as Dialog, Lexis/Nexis, and Dow Jones; the databases most pertinent to benefits valuation include: Enviroline, Pollution Abstracts, EconLit (Economic Literature Index), Social SciSearch, SciSearch, Medline, ABI/Inform, IAC Business A.R.T.S, Water Resources Abstracts, and WATERNET.

In addition, for several types of effects, bibliographies of relevant studies are available. For fatal human health effects, the list of studies currently referenced by EPA is provided in Chapter 3 of this document. For nonfatal human health effects, a list of available studies is provided in EPA’s *Cost of Illness Handbook* and in EPA's *Handbook for Non-Cancer Health Effects Valuation.* For ecological effects, analysts may wish to review EPA’s Environmental Benefits Database. Studies previously used by various EPA offices are identified in EPA's Environmental Economics Report Inventory.[5] Regardless of the bibliographic source used, analysts

[5] Available on EPA's website at http://www.epa.gov/economics.

typically read the studies themselves, rather than relying on summaries in these sources, because the characteristics that may significantly affect the benefit transfer are not always easy to capture in summary form.

Finally, additional valuation information may be available in unpublished studies or in studies currently underway. To identify these studies, the analyst may contact researchers frequently cited in the published literature, who are likely to be involved in or aware of other sources of valuation estimates. Staff from agencies who frequently support valuation research (such as EPA's National Center for Environmental Economics, the Fish and Wildlife Service, and the National Science Foundation) can provide information on relevant studies. Unpublished studies (which generally have been subject to less review than the published literature) are carefully reviewed to ensure that they are of sufficient quality to support defensible benefits estimates.

4.1.3 Step 3: Review Existing Studies for Quality and Applicability

Assessing the quality of existing research and its applicability to the policy scenario is the third step in benefit transfer. The guidelines in this section can serve as a road map for the analyst to follow in evaluating studies. In addition to reviewing the quality and applicability of existing studies, the analyst considers transferability issues, which are intertwined with the concept of applicability but refer to the steps followed in conducting the transfer. To avoid repetition, these "transferability" concerns are addressed under Step 4 below. A worksheet later in this chapter summarizes the guidelines for quality, applicability, and transferability.

It is not possible to develop absolute standards for assessing a study's quality and applicability. Rather, the analyst considers all of the factors discussed below, and balances the limitations of each study against the value of using it to provide information on the benefits of concern. For those studies ultimately used in the transfer, the analyst discusses the findings of the quality and applicability review when presenting the results. As indicated under Step 5, this discussion describes the extent to which the transfer is likely to overestimate or underestimate the value of the benefits derived from the regulation, given the uncertainties in the original study and in the transfer process.

Quality Issues

Quality refers to the appropriateness of the research methodology used, the care with which this methodology was implemented, and the accuracy and reliability of the resulting estimates. Considering these quality issues allows the analyst to identify sources of uncertainty related to the methods used to estimate values, and to weigh these sources of uncertainty in determining whether and how to use each study in a benefit transfer. Assessing quality requires a high degree of judgement in order to separate sound, scientifically valid studies from studies of lesser merit. The importance of particular criteria for assessing quality will vary depending on the type of study and the type of effect. However, there are some general criteria that analysts can apply to most research, which are discussed below.[6]

Opinion of the Professional Community: To a large extent, analysts rely on the opinions of the professional community in assessing the quality of a study. Analysts consider whether the research has been published in a peer-reviewed journal or has undergone other forms of peer review.[7] Analysts may also discuss the study with the original authors, leading researchers in the field, or the study's sponsor to learn more about its strengths and weaknesses and about whether these experts believe that the study conforms with "best practices" as defined by recent research.

Note that some studies that are well-respected in the field (because they explore new issues or apply innovative techniques) may not lead to reliable results in a benefit transfer; for example, if they are pilot studies that use a very small sample. In addition, there will not always be consensus on the merits of each study; analysts will need to take any areas of disagreement into consideration as part of their review and when conducting any subsequent transfer.

In some cases, the age of a study may affect its usefulness for benefit transfer due to concerns about changes in willingness to pay over time. However, use of older, well reviewed studies may be preferable to use of newer studies that have been subject to less scrutiny in some cases. Because of the need to balance these types of concerns, it is not possible to develop a universally applicable threshold for the age of studies. Rather, analysts will need to address this issue along with the other concerns discussed in this chapter.

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[6] For more specific information on assessing the quality of studies using particular valuation methods, see the references noted in the beginning of this chapter as well as the discussion in Chapter 3 of this document.

[7] For peer review standards, see: U.S. Environmental Protection Agency, *Peer Review Handbook*, January 1998.

Methods and Data Sources: When considering the quality of the methods used for the study, the analyst considers the appropriateness of the approach for valuing the effect of concern, as well as the extent to which the method is likely to yield accurate estimates of willingness to pay. For example, cost of illness methods may be used to value changes in health risks, but may not represent (or may understate) an individual's actual willingness to pay to avoid these risks. The extent to which different methods will yield conceptually correct measures of the value of benefits is discussed in Chapter 3 of this document.

When reviewing data sources, the analyst considers the accuracy, reliability, and completeness of the underlying records or information. For example, researchers using the wage-risk method have employed a multitude of data sources for information on compensation and job-related risks, and these data sources vary in terms of accuracy and completeness.[8] In addition, data sources that were developed many years ago may no longer reflect values held today. In the case of survey techniques, the appropriateness of the population sampled is considered in terms of location, age, and other characteristics that may influence willingness to pay. Literature review or survey articles provide professional opinions on these data quality issues and can assist analysts in assessing these concerns.

Sampling and Survey Administration: Many studies take a statistical sample of either data records or individuals. In these cases, analysts generally prefer studies that use probability sampling and sample sizes that are large enough to allow extrapolation to the underlying population with a reasonable level of confidence. Probability sampling allows the researcher to compute the chance that any particular individual within the population would be included in the sample and to develop appropriate weighting factors for extrapolating from the sample to the total population. While statistical measures of sampling error should be used to provide a more rigorous indicator of appropriate sample size, a rough guideline is that samples of less than 200 observations may result in unreliable estimates.[9]

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[8] See Viscusi, Kip, *Fatal Tradeoffs: Public and Private Responsibilities for Risk* (New York: Oxford Press, 1992) for an assessment of various data sources for wage-risk analyses.

[9] For contingent valuation surveys, Mitchell and Carson suggest that at least 600 useable responses are needed; the Water Resources Council recommends a sample size of 200. See: Mitchell, Robert Cameron and Richard D Carson, *Using Surveys to Value Public Goods: The Contingent Valuation Method,* Washington, DC: Resources for the Future, 1989; and U.S. Department of the Interior, Water Resources Council, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,* 1983.

Analysts consider the response rate (for surveys) or the extent to which complete records are available (for other types of studies). In the case of surveys, the response rate will vary depending on the method of survey administration: well-designed studies using personal interviews may achieve an 80 to 90 percent response rate, phone interviews may achieve an 85 percent response rate, and mail surveys may achieve a 60 to 75 response rate.[10] However, many surveys achieve lower response rates, and such rates will need to be considered along with other factors affecting the quality and applicability of a study when determining whether to use it for benefit transfer.

"Best practices" for survey development and administration, when contingent valuation or other survey methods are used, are discussed in the references provided in Chapter 3 of this document. In particular, extensive pre-testing of the survey instrument is generally needed to ensure that it is well understood and believable. Analysts interested in applying the results may wish to examine the survey instrument themselves to ensure that it is asking appropriate questions for valuation of the effect of interest and for control of confounding factors.

Data Analysis: Once the data are collected, researchers often analyze them using econometric or other statistical techniques.[11] Key concerns may include whether the theoretically correct variables are included in the analysis, the measures (or specification) of each variable, and the functional form of the equations or calculations employed.

If the original data set is available from the researchers, additional analyses may be conducted as part of the benefit transfer process, both to better understand the data and to adjust the estimates (or equations) for the transfer. For example, if the original study includes data on the age of respondents but does not explicitly assess the effects of this variable on the resulting values, the analyst conducting the transfer may explore these effects.

Evidence of Accuracy and Reliability: Finally, the analyst looks for evidence of the accuracy and reliability of the estimates. Accuracy refers to how precise, or correct, the findings are; for example, how well the sample results mirror the value in the underlying population. Reliability refers to the extent to which the findings can be replicated; for example, whether applying the survey to a second sample would result in the same or similar estimates. At the most basic level, accuracy and reliability may be assessed based on information from the researchers on how they designed the study, checked the data, calculations, and results, and addressed key

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[10] Dillman, Don A., *Mail and Telephone Surveys: The Total Design Method,* New York: John Wiley and Sons, 1978.

[11] See, for example: Greene, W.H., *Econometric Analysis, 4th Edition,* New Jersey: Prentice-Hall, 2000.

sources of uncertainty. The analyst may also consider whether the study yields estimates that are in the range found by other studies of similar effects; evidence that study findings have been replicated by other researchers is often the best test of reliability. Finally, the analyst generally assesses whether the results are consistent with general economic theory. For example, he or she may question the quality of a study that found lower values for mitigation of severe adverse effects than for mild effects.

Applicability Issues

In the context of benefit transfer, applicability refers to the extent to which the existing research (the study case) matches the policy case. Applicability therefore involves comparing the effect studied to the description developed under Step 1 above, which again requires a high degree of judgement on the part of the analyst. Three main areas of concern are the similarity of the effect, the population, and the baseline conditions.

Similarity of Effect: The similarity of the effect can be determined by an "item-by-item" comparison of the description of the policy case (developed under Step 1) to the description of the case addressed in each existing study. The analyst generally considers the divergence in physical attributes, severity, timing and duration, etc., as well as the magnitude of the differences. For example, if the contaminant in question is associated with developmental effects, and the existing research focuses on the effects of lead, the analyst would consider the extent to which the developmental problems caused by lead are similar to developmental problems caused by the contaminant.

In reviewing the similarity of the effects, analysts generally consider dimensions of risk in addition to the physical manifestation of the effect, such as the following:

- voluntary/involuntary
- ordinary/catastrophic
- delayed/immediate
- natural/man-made
- old/new
- controllable/uncontrollable
- necessary/unnecessary
- occasional/continuous
- acute/chronic

These risk dimensions may affect willingness to pay to reduce different types of risks. For example, individuals may hold different values for reducing lung cancer risk from smoking (e.g., if they perceive it as a personal lifestyle choice) than from environmental causes (e.g., if they perceive these risks as beyond their control).[12] The impact of risk characteristics on the valuation estimates are generally discussed qualitatively because the empirical data needed to adjust for these impacts have not yet been developed.

For certain effects, high quality valuation literature on similar effects may not exist, and the analyst will have to make judgments about the suitability of other valuation studies. For example, EPA recently used data on chronic bronchitis to value the benefits of avoiding non-fatal bladder cancer associated with regulating drinking water disinfectant by-products.[13] The researchers did not find any willingness to pay studies for non-fatal bladder cancers or other similar cancers. They decided to use chronic bronchitis as a proxy effect, on the grounds that chronic bronchitis and bladder cancer have certain commonalities, such as severity and long-term impacts. They compared the resulting willingness to pay values to cost of illness values for non-fatal bladder cancers as a check on the reasonableness of the estimates.

This use of proxy effects that have dissimilar manifestations to the effects of the policy case may provide useful information for decision-making (e.g., by indicating the range or potential magnitude of benefit values). However, this approach is controversial and requires careful consideration of the limitations of the analysis. Decisions regarding whether to use valuation information for dissimilar effects are made on a case-by-case basis because they will depend on the nature of the issues being addressed as well as the available valuation data. In these situations, analysts work to clearly communicate the advantages and drawbacks of using the chosen study case, and the implications of these concerns for related decision-making. For example, analysts may list and compare characteristics of the proxy and the policy effects, and discuss their expected net impact on willingness to pay, when describing the results of the analysis.

Similarity of Population: In addition to reviewing the similarity of the effects, the analyst compares the population studied to the population affected in the policy case. Populations can differ by geographic location as well as by demographic or socio-economic factors such as age, sex, income and race. The analyst generally focuses

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[12] Fischoff, B. et al., "How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits," *Policy Sciences*, Vol. 9, 1978, pp. 127-152.

[13] The Cadmus Group and Science Applications International Corporation, *RIA for the Stage 1 Disinfectants/Disinfection Byproducts Rule,* prepared for the U.S. Environmental Protection Agency, 1998.

on those dimensions that are associated with potentially significant differences in willingness to pay.[14]

In some cases, the analyst can adjust for population-specific factors by including relevant variables in a valuation function or by only using part of a data set (if possible without adversely affecting the statistical validity of the sample). In other cases, such adjustments will not be possible, and the differences between the populations introduce another layer of uncertainty into the benefit transfer process that can be discussed when presenting the results. For example, if the policy case is exploring the effects of a particular contaminant on children's health, and the study case has analyzed adult health values, the analyst considers whether there is a scientifically valid way to adjust for the difference in effects between the two populations. EPA is currently addressing the many complex issues that arise in this case, and is developing guidance focused particularly on valuing children's health effects.

Similarity of Baseline: The third major area to consider is whether baseline health status, or in the case of an ecological effect, environmental quality, is similar between the policy case and the study case. Willingness to pay to avoid health effects may vary depending on whether the individuals affected are in good or poor health, or have a particularly high risk of being affected compared to others exposed.[15] This difference in baseline health status may be particularly important for sensitive populations (such as those with suppressed immune systems, the elderly, or children) who are more vulnerable to the effects of drinking water contaminants. Individuals are also likely to hold different values for ecological effects resulting from a marginal decrease in contamination in routinely polluted waters than for the same decrease in contamination in more pristine areas.

4.1.4 Step 4: Transfer the Benefit Estimates

The fourth step of the benefit transfer process is to derive values from the study case and apply them to the policy case. The researcher can adjust and transfer values in a number of different ways, but the techniques generally fall into three categories: (1) applying a point estimate (i.e., a single value); (2) using a valuation function (an equation that relates values to characteristics of the effect and/or the population affected); or, (3) using meta-analysis or Bayesian approaches (which combine the results of several studies). These approaches are listed in order of increasing complexity, and (all other things being equal), the more complex approaches will often lead to better estimates. However, the available literature may not be sufficient

[14] Addressing some of these factors may be controversial. For example, if willingness to pay appears to vary by income or race, consideration of this variation may raise environmental justice concerns as discussed in previous chapters of this document.

[15] As noted in the discussion of fatal risk valuation in Chapter 3, the consideration of altruistic values is somewhat controversial and should be approached with caution.

to support use of the more sophisticated approaches, and analysts generally assess these transferability issues when reviewing the available studies.

Point Estimate. A point estimate refers to the process of taking a single estimate for a particular value (often the mean or median) and using it to directly approximate the value in the policy case. Reasonable high and low values (e.g., the 10th and 90th percentile of a distribution) may also be used for bounding or sensitivity analysis. In the most simple case, the analyst will take the mean or median value from the study case and multiply it by the number of statistical cases avoided (for health effects) or the population affected (for ecological effects) by the regulations.[16,17] This type of simple transfer may be useful particularly for initial screening analysis, but does not account for any dissimilarities in the nature of the effects, the population characteristics, or the baseline status. Hence its use is generally limited to cases where the underlying research will not permit a more sophisticated approach. In such cases, the differences between the policy case and the study case are usually discussed quantitatively when presenting the results.

A more sophisticated approach involves tailoring point estimates to the particulars of the policy case through simple adjustments; for example, adjusting for changes in income over time. This type of tailoring improves the transferability of the estimates, and may be the only technique an analyst can employ when the valuation function for the study case is not available.

Benefit Function. The benefit function approach is possible when a valuation function is provided in the study case or can be calculated from the data set. For example, the study may include age and income in an econometric equation that predicts willingness to pay. The benefit function approach utilizes the additional information provided by the function and tailors it by substituting values from the policy case into the function. In other words, data on the age and income of individuals affected by a particular regulation can replace the data from the study case to yield an appropriate value or range of values. In some cases, the valuation function provided in the original study will include information not available for the policy case, such as attitudinal variables. In this case the analyst may wish to re-estimate the equation based on the variables for which data are available if appropriate given the nature of the study.

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[16] A statistical case is calculated by multiplying the number of individuals affected by quantified risk factors. An example of this calculation is provided in the discussion of mortality risks in Chapter 3.

[17] When using benefit transfer to value ecological effects, the analyst often addresses difficult issues regarding the population assumed to value the change, referred to by economists as the "extent of market." For example, for recreational benefits, the study case may focus on households located within a set distance of the site, and the analyst conducting the transfer determines whether this assumption is appropriate for the policy case sites, and if not, how to adjust appropriately.

Because the benefits function approach is better tailored to the policy case than the point estimate approach, it can provide an improved estimate of the value of the benefits. However, one potential problem with this approach is its reliance on the equality of coefficients between the study and policy cases. This approach will still involve additional uncertainty if the two cases differ in ways that are not addressed by the valuation function (e.g., if baseline health conditions differ but are not included in the function resulting from the original case).

Meta-Analysis or Bayesian Approaches. The most complex transfers use statistical methods such as meta-analysis or Bayesian approaches, which combine estimates from several studies of similar effects.[18] Meta-analysis can be used to integrate the results when many relevant studies are available; the Bayesian approach includes data on the policy case as well as from existing studies.[19] These approaches have been used more frequently for ecological effects than for health effects because of the availability of larger numbers of applicable studies. Because these approaches draw on more data sources than a single study and use statistical techniques to explore the variation in the results, the resulting estimates may be more accurate and reliable than point estimates or valuation functions. However, meta-analysis and Bayesian approaches require a high level of technical expertise and can be very time consuming to implement. These approaches are also data intensive and may not be feasible for many effects due to the lack of relevant studies. Thus, analysts generally apply these techniques with caution and involve relevant experts in developing and reviewing the analysis.

With all of these transfer techniques, the analyst need to aggregate individual estimates over the population experiencing the effect. The aggregation process may be designed to take into consideration such issues as bias and distributional effects. For example, if separate values are available for a sensitive sub-population and for the remainder of the general population (minus the sensitive sub-population), the total value of the benefits for each group can be calculated separately and then added together to estimate benefits for the entire population.

4.1.5 Step 5: Address Uncertainty

Uncertainty permeates all the steps of the transfer process, from selecting appropriate studies and manipulating data to establishing a range of values. Each of the existing studies used in the transfer will itself contain uncertainties that result both from the

[18] For more information see Desvousges (1998), and Atkinson et al., "Bayesian Exchangeability, Benefit Transfer, and Research Efficiency," *Water Resources Research* 28(3) 715 - 722, March 1992.

[19] For an example of meta-analysis, see Boyle, K.J., G.L. Poe, and J.C. Bergstrom. "What do We Know about Groundwater Values? Preliminary Implications from a Meta-Analysis of Contingent-Valuation Studies," *American Journal of Agricultural Economics,* Vol. 76, pp. 1055-1061, December 1994.

data and analytic approach used as well as from difficulties related to thoroughly understanding the preferences of the individuals studied. However, the presence of uncertainty does not imply that the resulting values are random or indeterminable. By using techniques such as sensitivity analysis or more complex models such as Monte Carlo simulations, the analyst can, to a certain degree, quantify the effects of uncertainties in the estimates used in the benefit transfer.[20] As noted earlier, those uncertainties that cannot be quantified are generally discussed in qualitative terms when presenting the findings of the benefit transfer. In this discussion, analysts describe the relative importance of each source of uncertainty as well as the direction of the possible bias, if known.

4.2 Benefit Transfer Worksheet

The worksheet presented on the next pages summarizes the key questions discussed in the previous sections on quality, applicability, and transferability. Because it is designed as a general tool, the worksheet does not provide a comprehensive framework appropriate for every benefit transfer situation. Rather, it categorizes the most common issues in a format to facilitate further analysis.

[20] For more information on uncertainty analysis, see: Morgan, Granger M., and Max Henrion, *Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis,* Cambridge University Press: New York, 1990.

Exhibit 4-1
Sample Worksheet For Review of Valuation Studies

GUIDELINE	QUESTIONS TO ASK	COMMENTS
Quality Issues		
Opinion of the Professional Community	Has the study been published in a peer-reviewed journal or been subject to other types of peer review? What are the strengths and weaknesses of the study according to experts in the field?	
Methods and Data Sources	Is the methodology used appropriate for the subject of the study? Has the methodology been widely used in similar studies? What are the strengths/weaknesses of the methodology? Are the study's data sources appropriate for the subject? What are the strengths/weaknesses of the data sources used?	
Sampling and Survey Administration	Does the study use appropriate probability sampling techniques? Is the sample size large enough? Is the response rate reasonably high? If a survey was conducted, was it adequately pre-tested? Was the survey administration technique (mail, phone, or in- person) employed following standard "best practices"?	
Data Analysis	Are the appropriate variables correctly specified and included in the analysis ? Is the appropriate functional form used for the calculations? Is the data set available for further analysis?	

Exhibit 4-1
Sample Worksheet For Review of Valuation Studies

Evidence of Accuracy and Reliability	Is the study well documented? How were data, calculations, and results validated by the researcher? Are the effects of key uncertainties thoroughly described? Was a quantitative uncertainty analysis performed? When compared to other studies, are the findings reasonable? Are the findings consistent with economic theory?	
Applicability Issues		
Similarity of Effect	How does the effect analyzed in the study case compare to the effect of the policy case? What is the magnitude of the difference? Are the timing and duration of the effects similar?	
Population Affected	How does the population addressed in the study case compare to the population addressed by the policy case (e.g., in terms of age, geographic location, income, etc.)?	
Baseline Conditions	How similar is the policy case baseline (e.g., health status or environmental quality) to the study case conditions? Are there any characteristics of the individuals, ecological systems, or water systems in the policy case that render them more or less susceptible to the effect than the subject of the study case?	
Transferability Issues		
Opportunities for Adjustment	Does the data set from the original study contain information that allows for better tailoring of the study case to the policy case? Is a valuation function reported that can be transferred to the policy case? Are enough studies of similar effects available to use meta-analysis or Bayesian approaches to combine the results?	

IMPLEMENTING BENEFITS ANALYSES CHAPTER 5

The previous chapters provide information on the requirements and methods for benefits assessment; this chapter discusses considerations related to implementing these types of analysis. It discusses issues related to sequencing the analysis, such as using screening tools to develop preliminary benefits estimates and to focus subsequent research. It also describes the basic steps in conducting benefits analyses, including identifying potential benefits, quantifying physical effects, and determining the monetary value of the effects. It then discusses some issues that relate to both the cost and benefit analyses, such as the definition of the baseline and the selection of discount rates.

5.1 Sequencing The Analysis

The EPA regulatory development process includes several phases of analysis and decision-making that often occur over several months or years depending on the complexity of the rulemaking. Both the internal EPA work group and stakeholder groups involved in developing and evaluating regulatory alternatives often find information on the potential benefits (and costs) of the options under consideration useful in their deliberations throughout this process.

To meet this need for early information on the benefits of different regulatory approaches as well as to focus resources on key issues, analysts generally find it helpful to adopt a sequential approach to data collection and analysis. Under this approach, the analyst begins with available data and relatively simple analyses, then refines the data and analyses as needed. The approach is illustrated in Exhibit 5-1 and discussed in the following sections.

Exhibit 5-1
Phases of the Analysis

Phase 1: **Conducting scoping and screening analysis,** using available information and relatively simple analytical methods to provide information on possible effects and focus future efforts.

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Phase 2: **Refine the analysis,** collecting additional data and applying more complex analytic tools as needed.

↓

Phase 3: **Report the results,** clearly communicating the findings and related uncertainties.

Note that while the exhibit identifies reporting the results as a distinct final step for simplicity, the principles discussed below also apply to interim briefings or preliminary reports on earlier phases of the benefits analysis.

A critical advantage of sequential analysis is that it allows analysts and decision makers to apply an informal "value of information" approach to the performance of the benefits assessment, considering whether the time and expense of additional research and data collection are warranted at each stage in the analysis. In some cases, screening analysis alone may prove sufficient to support a regulatory decision. For example, the results of a screening analysis of benefits may be clear, persuasive, and certain enough to justify establishing the MCL at the lowest feasible level without additional analysis. In other cases, the conclusions of the analysis may not clearly support the choice between the lowest feasible level and less stringent alternatives. Analysts can then use the results of a screening study to focus subsequent efforts on those areas where more detailed investigation is most needed. In each stage, analysts work to clearly document the methods used in the analysis, its findings, and related uncertainties.

5.1.1 Conduct Scoping and Screening Analysis

The first step in conducting a benefits assessment is to collect and evaluate readily available information on the nature and extent of potential benefits associated with the proposed regulation. Because this information is typically used to define the scope of the overall assessment, this step is often referred to as "scoping analysis." This stage includes both review of the available literature and informal discussions with other EPA staff and management, outside experts, and stakeholders.

Once the available information has been collected and reviewed, the next step may involve performing a "screening" analysis to develop initial benefits estimates and identify areas where more investigation is needed. Screening analyses will often involve the use of benefit transfer techniques to value selected effects, as discussed in the Chapter 4. The results of these analyses may be used to provide decision-makers with preliminary information on the potential benefits of alternative MCLs or treatment requirements, as well as to define more clearly those areas where additional research is most needed to support decision-making. For example, analysts may find that uncertainties in the risk estimates are substantial and far outweigh uncertainties in the economic valuation data. Additional research could then be focused on refining the risk assessment rather than the valuation estimates.

5.1.2 Collect and Analyze Additional Data as Needed

Following completion of the screening analysis, the next step in the benefits assessment is to collect and analyze additional data that will reduce uncertainties or gaps in the preliminary benefits estimates. The exact steps undertaken will depend on the nature and importance of the issues to be addressed as well as the time and resources available for the analysis. Options for collecting additional data may include conducting a census or survey, developing case studies, or interviewing pertinent experts.[21] New supporting analysis may also be developed; for example, analysts may commission more primary research on the value of key benefits or use more formal techniques (such as meta-analysis, which uses statistical methods to combine the results of similar studies) in applying the results of available studies. In addition, analysts may attempt to better define areas of uncertainty, either by conducting additional bounding or sensitivity analysis or by applying probabilistic methods (such as Monte Carlo modeling).[22]

Decisions about when to stop the analysis (i.e., when do we have enough information on benefits, with an appropriate level of certainty?) involve interaction between the EPA staff responsible for the cost and benefits analyses and senior managers. The costs and time required for additional analysis is balanced against the likely value of new information for decision-making. Analysts may consider the probability that the new information will significantly reduce uncertainty or improve the ability of decision-makers to select among alternative MCLs or treatment requirements.

5.1.3 Communicate the Results

As the benefits assessment proceeds through the phases described above, analysts are likely to be asked periodically to brief others involved in the regulatory development process (such as Agency management, work group members, and stakeholders) on their findings. In many cases, these audiences may be unfamiliar with the theory and methods of benefits analysis and with the advantages and limitations of various approaches. Communicating effectively to all of these groups involves tailoring the presentation to each audience's level of understanding and interests. An audience composed of EPA economists, for example, is likely to have different interests (as well as a differing level of familiarity with the topics) than would a citizens' group concerned with children's health risks.

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[21] All data collection must be conducted in compliance with the Paperwork Reduction Act, under which OMB approval is needed for efforts that pose the same or similar questions to more than nine respondents.

[22] For more information on applying this framework to policy analysis, see: Morgan, Granger M., and Max Henrion, *Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis,* Cambridge University Press: New York. 1990. For specific guidance on Monte Carlo analysis, see: U.S. Environmental Protection Agency, *Guiding Principles for Monte Carlo Analysis,* March 1997.

Regardless of the background or interests of the audience, analysts generally focus on presenting the results of the benefits assessment in plain English, using simple charts and graphics as appropriate to help communicate key findings. In addition, the presentation may note the uncertainties in the analysis and their implications for decision-making. For example, analysts may both point out the limitations ("the valuation estimates do not include several minor health effects") and to note the implications for decision-making ("these minor impacts may mean that total benefits exceed total costs by a greater amount than indicated by the quantified values").

Text discussions of these concerns are usually accompanied by tables and graphics that summarize key findings. Exhibit 5-2 provides an example of a table that presents analytic results, key uncertainties, and nonquantified effects. This table may be expanded to include costs for comparative purposes, or costs may be presented in a similar, but separate, format.

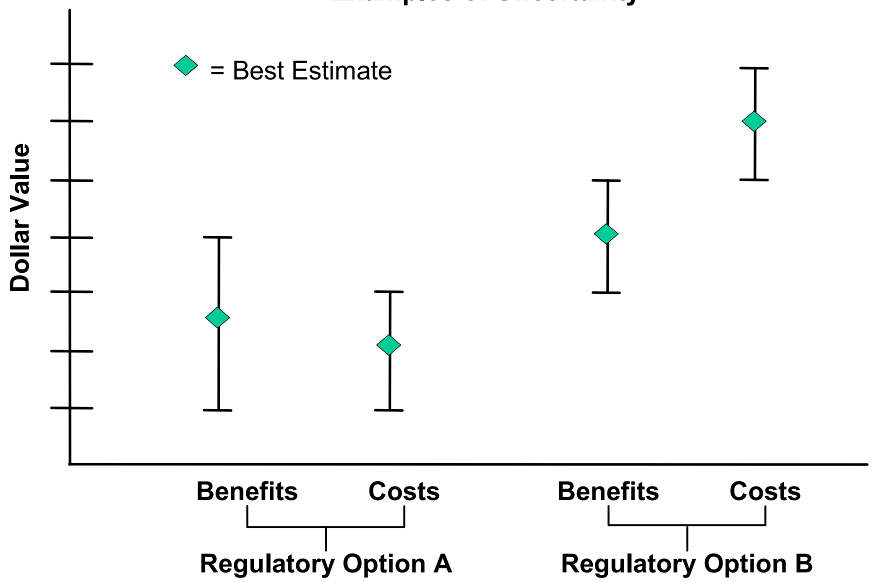
Exhibit 5-2
Sample Summary Table

Regulatory Option	Type of Benefit	Best Estimate	High End Estimate	Low End Estimate
MCL = Xμ/L	Stomach Cancer	$X million	$XX million	$0.X million
	Kidney Disease	$X million	$XX million	$0.X million
	Developmental Effects	Not quantified. Limited available research suggests possible association with low birth weight.		
MCL = Yμ/L	Stomach Cancer	$Y million	$YY million	$0.Y million
	Kidney Disease	$Y million	$YY million	$0.Y million
	Developmental Effects	Not quantified. Limited available research suggests possible association with low birth weight.		

This type of table may be used to report the absolute value of the benefits for the baseline and each regulatory option, and/or the incremental change between options of increasing stringency.

An example of a graphic presentation of the uncertainty in the estimates is presented in Exhibit 5-3.

Exhibit 5-3
Examples of Uncertainty



Note: Nonmonetized costs and benefits should be identified in the notes on the exhibit.

The final results of the analysis are documented as part of the regulatory impact analysis (now generally referred to as the "economic analysis") prepared for the proposed and final regulations and placed in the public docket. This report is written in plain English for a general audience and includes simple tables and graphs that clearly communicate the approach, the results (including nonquantified effects), related uncertainties, and implications. All sources are referenced, and appendices are often used to report detailed analytic results as necessary. In general, the results of the risk assessment are presented separately from the economic valuation of benefits, due both to the importance of the risk data and the complexity of the issues that must be addressed.[23]

5.2 Steps in the Benefits Analysis

In each phase described above, the benefits analysis generally includes three steps: (1) identify the types of benefits; (2) quantify physical effects; and (3) estimate the monetary values of these effects. Exhibit 5-4 illustrates the relationship between the

[23] For more information regarding the presentation of the benefits valuation analysis, see U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses,* EPA 240-R-00-003, September 2000.

phases of the analysis described above and these three steps. We discuss these steps in greater detail below.

Exhibit 5-4

Relationship Between Phases and Steps

Phase 1: Conduct scoping and screening analysis	Step 1: Identify potential types of benefits, including the full range of possible effects.
	Step 2: Quantify physical effects, focusing on key benefits and using available information.
	Step 3: Estimate the dollar value of the effects for key benefits, based on available valuation studies.
Phase 2: Refine the analysis as needed	Step 1: Refine the understanding of potential types of benefits, extending the analysis to include additional types of benefits if relevant.
	Step 2: Refine the estimates of physical effects, collecting additional data and/or performing additional analysis to address key uncertainties.
	Step 3: Refine the estimates of the value of the effects, collecting additional data and/or performing additional analysis to address key uncertainties.
Phase 3: Communicate the results	Step 1: Discuss the process and rationale used to select benefits for analysis, including information on any benefits that were not quantified or monetized.
	Step 2: Describe the methods used to quantify physical effects and the analytic results, including information on related uncertainties.
	Step 3: Describe the methods used to estimate the dollar value of the effects and the analytic results, including information on related uncertainties.

5.2.1 Identify Potential Benefits

In Chapter 1, we introduced three main categories of benefits related to regulations establishing MCLs or treatment requirements: human health effects, aesthetic effects, and effects on materials. Regulations leading to increased source water protection may also have ecological effects. Effects on human health are assessed for all regulations establishing MCLs, and that other effects are generally assessed as relevant to the particular regulation.

The first step in the benefits analysis is to develop a list of the effects in these categories that may be mitigated by the particular regulation, based on review of the relevant literature and consultations with experts. These experts may include risk assessors as well as others knowledgeable about the physical impacts of the contaminants.

In developing this list, analysts generally consider both the types of effects associated with the contaminant and the contaminant concentrations that are necessary to cause the effect. In some cases the regulations will not be sufficient to alter the effect of concern. For example, some health effects may not occur even in the baseline because contaminant concentrations are below the threshold levels for incidence of the effect. In other cases, the difference between baseline concentrations and alternative MCLs may not be sufficient to change the incidence of the health effect. Thus, in addition to identifying the potential effects of the contaminant, this step includes assessing whether each type of effect might be mitigated by the regulatory options under consideration.

At the outset of the analysis, information on baseline concentrations and possible MCLs may be sketchy and presented as broad ranges. Hence the range of possible beneficial effects may be relatively large. For example, the initial list of benefits potentially resulting from controlling a particular contaminant may include several types of fatal and nonfatal health effects, as well as some aesthetic effects. As more information becomes available on baseline and post-regulatory contaminant concentration levels, the list may be trimmed to exclude those types of benefits not likely to accrue.

While it is useful to develop a comprehensive list of possible benefits, some of these benefits may not be subject to detailed assessment. The detailed analysis generally focuses on significant benefits, including those effects that meet one or more of the following criteria: (1) there are likely to be observable changes in the effects when comparing alternative MCLs to each other and to the baseline; (2) the effects may account for a major proportion of the total benefits of the rulemaking; and/or, (3) stakeholders or decision-makers are likely to require information on the effects, even if their magnitude is relatively small. For example, if the contaminant is linked to an illness that particularly affects children, analysts may assess the effect of the regulation on the illness even if the number of cases is relatively small, given the emphasis of SDWA and other mandates on children's health effects. Any benefit categories that are not quantified or valued are discussed qualitatively when presenting the results of the analysis.

5.2.2 Quantify Physical Effects

The next step in the analysis involves quantifying the physical effects of the regulations -- e.g., determining the effect of the regulations on the risks of incurring specific diseases or on the level of corrosion in water system piping. These estimates are generally obtained from health scientists and risk assessors in the case of health effects, and physical scientists or engineers for other types of impacts. EPA's framework for risk assessment and other references provide detailed guidance on risk assessment; analysts generally review the available literature and consult with relevant experts as needed to determine how to quantify other types of effects.[24]

For health effects, this step results in detailed descriptions of the physical effects likely to be avoided by the regulations -- e.g., the types and severity of the illnesses. For each type of health effect, detailed data are also developed on the change in risk and the change in the number of statistical cases (including mortality rates) attributable to the regulation, the timing of the changes, and the demographics of the affected population. The uncertainty associated with these estimates is also explored.

For example, risk assessors may indicate that a specific MCL will reduce the annual, average individual risk of incurring a particular type of kidney disease by 1/10,000, decreasing the number of statistical cases (given the size of the population affected by the regulation -- in this example, 50,000) by the equivalent of five cases per year. Risk assessors may also note that about half of these cases would be fatal, and that the fatalities reduced by the regulation would primarily be among elderly members of the population. Furthermore, uncertainty analysis may indicate that the number of cases avoided may be understated or overstated by a factor of four.

Analysts generally develop similar types of information for other types of effects. For example, for corrosive contaminants, engineers may be asked to estimate the miles of piping affected, the degree of decrease in corrosion attributable to setting the MCL at different levels, the effect of the decrease on the timing and extent of pipe replacement, and the amount of uncertainty in these estimates.

As noted earlier, some benefits may not be quantified, either because the scientific basis for quantifying them is not well-established (e.g., data are lacking on the link between exposure and disease incidence) or because the time and resources required to perform the analysis outweigh the usefulness of gathering the additional information for decision-making. These benefits are discussed qualitatively when presenting the results of the benefits analysis.

5.2.3 Estimate the Value of the Effects

Once the physical effects of the regulation are quantified, analysts may use the methods described in Chapters 3 and 4 to estimate the dollar value of these effects. Below, we provide simplified examples of this step for mortality, morbidity, and other impacts. These examples are intentionally brief to illustrate the types of

[24] See, for example, U.S. Environmental Protection Agency, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, December 1989; U.S. Environmental Protection Agency, *Guidance for Risk Assessment,* prepared by the Risk Assessment Council, November 1991.

approaches that may be used. In reality, assessing these impacts is likely to be substantially more complex due to limitations in the available data and other factors.

Example 1: Mortality Valuation. As discussed in Chapter 3, available research provides value of statistical life estimates ranging from $0.8 million to $17.8 million, with a mean value of $6.3 million (2000 dollars).[25] Using a Weibull distribution, the 10th and 90th percentile values are $1.6 million and $12.3 million respectively. These values apply to small changes in the risk of premature mortality among a population; they are not values for saving the life of a particular individual.

In the screening phase of the analysis, these estimates can be simply applied to initial estimates of the number of statistical lives saved to provide a preliminary indicator of the value of these benefits. The results of this analysis, for a regulation that reduces the risks of premature death by the equivalent of five statistical lives per year, would be as follows.

Exhibit 5-5
Example of Screening Analysis for Valuing Mortality Effects
(2000 Dollars)

Low End Estimate (10th percentile value)	Mid-Range Estimate (mean value)	High End Estimate (90th percentile value)
$8.0 million (5*$1.6 million)	$31.5 million (5*$6.3 million)	$61.5 million (5*$12.3 million)

The above example is intentionally simplified and an actual benefits analysis may be significantly more complicated. For example, analysts may perform a sensitivity analysis to account for uncertainty in the risk estimates; e.g., using reasonable upper and lower estimates of the number of statistical lives saved to help bound the benefits estimates, or applying a probabilistic model to estimate the likelihood of different outcomes. In addition, the biases that are introduced by using the available valuation literature (which largely addresses fatalities from work place accidents rather than environmental contaminants) may be addressed qualitatively or quantitatively, as discussed previously in Chapter 3.

Example 2: Morbidity Valuation. As Chapter 3 notes, values for avoiding nonfatal health effects will vary greatly depending on the nature and severity of the effect. Monetary values for several of the health effects associated with drinking water contaminants are provided in EPA's *Cost of Illness Handbook* and *Handbook*

[25] U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act: 1990 to 2010,* EPA 410-R-99-001, November 1999.

on Noncancer Health Effects Valuation. These estimates include both cost of illness (COI) and willingness to pay (WTP) values; willingness to pay estimates are available for a relatively small number of health effects.

For the purpose of this example, we assume that the regulations will reduce, by 15 statistical cases, a specific type of kidney disease per year. We further assume that available COI estimates indicate that the costs of this illness (medical expenses and lost work time) average about $25,000 per case. In addition, we assume that WTP values for similar (but not identical) illnesses are approximately $45,000 per case. The results of a very simple screening analysis using these estimates is provided in Exhibit 5-6.

Exhibit 5-6
Example of Screening Analysis for Valuing Morbidity Effects
(1999 Dollars)

Cost-of-Illness (COI) Estimate	Willingness to Pay (WTP) Estimate
$375,000 (15*$25,000)	$675,000 (15*$45,000)
Note: The COI estimate is likely to understate the actual value of reducing these health effects, because it does not address pain and suffering or other effects associated with the disease. The WTP estimate accounts for these other effects, but is for a disease similar but not identical to the illness reduced by these regulations.	

In this case, the note in the exhibit would be explained in detail in the text; this discussion could address the likely direction and magnitude of the associated biases to the extent possible. Issues related to the quality, applicability, and transferability of the studies used to develop these estimates may be discussed in detail, as described in Chapter 4. For example, the WTP estimate may understate actual willingness to pay if it is for a less severe form of the illness or for a form with shorter duration. In this example, total benefits would be at least $375,000, but could exceed $675,000 since the WTP estimates probably understate the actual value. Sensitivity or probabilistic analysis could be performed to account for uncertainty in the risk (or valuation) estimates. This simple example does not reflect many of the considerations that might be addressed in an actual analysis, such as the rationale for using a point estimate to value these effects rather than a function that relates this value to the characteristics of the population affected and other determining factors. In subsequent stages of the analysis, this approach to valuation could be refined.

More information on valuing morbidity effects, including several examples, is provided in EPA's *Handbook on Noncancer Health Effects Valuation.*[26]

Example 3: Valuation of Other Impacts. Chapter 3 also describes methods for valuing other types of benefits, such as reduced damages to materials and aesthetic effects. In many cases, the non-health effects of drinking water regulations may be valued using the avoided cost method. This method compares expenditures with and without the regulations to estimate the value of related benefits.

To illustrate this approach, consider a regulation that reduces the corrosion of pipes, which in turn will decrease the frequency of needed repairs and/or replacement. The value of this decreased maintenance and replacement (e.g., per mile of piping) could be estimated by engineers with relevant expertise, then applied to estimates of the length of piping potentially affected by the regulations. As in the mortality and morbidity examples, a simple approach could be applied for screening purposes, then refined if needed to provide better information for decision-making in subsequent phases of the analysis. For example, one refinement would be to consider the extent to which changes in costs would lead to changes in prices, and to re-estimate the benefits values to take into account the resulting change in consumer or producer surplus.

5.3 Cross-Cutting Issues

The previous discussion has focused primarily on issues that relate to the benefits analysis. There are also several cross-cutting issues that are addressed in both the cost and benefits analyses. We discuss two key considerations in more depth — discounting and inflation — and then provide a short overview of several other cross-cutting issues for benefits analyses under SDWA.

5.3.1 Discounting and Inflation

Analyses of the costs and benefits of drinking water regulations may be conducted on an annual basis, or may consider impacts over a number of years. The appropriate time frame for the analysis is determined on a case-by-case basis. In general, the annual approach may be most appropriate in cases where costs and benefits are expected to be relatively constant from year to year once the regulation is implemented. If costs and benefits accrue in different time periods or are likely to change significantly over time, the analysis may cover a multi-year period. For example, if EPA is considering whether to allow water systems to gradually comply with a new standard over a several year period, analysts may wish to compare the

[26] U.S. Environmental Protection Agency, *Handbook on Noncancer Health Effects Valuation (draft),* prepared by Industrial Economics, Incorporated, September 1999.

costs and benefits of the phased approach to the effects of requiring more immediate compliance.

Regardless of the time period selected, analysts are likely to need to work with data on monetary values that were collected at different points in time. For example, recent compliance cost data may be available, but benefits valuation studies may be several years old. Two important factors affect the dollar value of costs and benefits over time — discounting and inflation. These terms apply to two very different concepts. Discounting is a method that accounts for alternative, productive uses of funds over time. Inflation refers to an overall rise in price levels. Below, we discuss each of these factors in more detail and provide an overview of EPA and OMB guidance on selecting a discount rate.

Inflation

Inflation refers to an overall rise in general prices throughout the economy; it is often measured by comparing the average prices of a standard bundle of goods and services across time. Inflation does not reflect a real increase in value; rather it indicates that the same goods and services now command higher prices. Information on inflation rates in available in the *Economic Report of the President*, which is published annually by the Executive Office of the President. This report includes both general inflation rates (the best known of which is the consumer price index or CPI) as well as rates for specific types of goods and services (e.g., the CPI-medical); the appropriate rate depends on the types of goods or services under consideration. These factors can be used to inflate prices incurred in prior years to the present or to decrease (deflate) current prices to a prior level.

For example, if a valuation study reports estimates as 1990 dollars, and an analyst wishes to covert to 1999, dollars using the CPI, he or she would first determine the change in the CPI over this time period. According to the 2000 *Economic Report of the President*, the CPI rose from 130.7 to 166.6 over this time period, or about 127 percent. The analyst would multiply the 1990 value by 1.27 to determine the 1999 equivalent.

To compare costs and benefits through time, analysts remove the effects of inflation from the estimates. Otherwise, it is difficult to disentangle real changes in value from changes that are attributable only to inflation. The OMB guidance recommends deflating benefit and cost estimates that are in nominal dollars by an appropriate inflation index to get constant dollar estimates.[27] In other words, cost and benefit estimates should be presented in real terms based on a specific year. Because of the

[27] U.S. Office of Management and Budget, "Guidelines to Standardize Measures of Costs and Benefits and the Format of Accounting Statements" Appendix 4 in *Report to Congress on the Costs and Benefits of Federal Regulations,* March 22, 2000.

uncertainties related to estimating future inflation, both costs and benefits are generally reported as of the most recent completed year for which inflation rates are available. For example, an analysis completed in 2001 might be reported in 2000 dollars.

Discounting

Discounting differs from inflation in that it measures real changes in value over time. When a water system invests in new treatment technology, or an individual invests in a home water filter, the investment means that the funds are not available for other productive uses. These alternative uses are referred to as "opportunity costs" by economists. In general, individuals prefer to have resources available in the near term rather than in the future, because they can invest the resources and receive a return on their investment. The same is true of consumption, individuals would generally prefer to consume desired goods or services soon rather than waiting.

Discounting is a method for adjusting monetary values to reflect these time preferences. Discounting future costs or benefits involves multiplying the value in each year by a factor that adjusts for both the length of time between the present and when the event occurs and the degree to which current investment (or consumption) is valued over future investment (or consumption). Discounting allows costs and benefits that occur in different time periods to be compared by stating them all in current year terms, referred to as the "net present value." The net present value of a stream of costs and benefits is calculated by multiplying the costs and benefits in each year by a time-dependent weighting factor and summing the results. The rate of change assumed over time is referred to as the "discount rate."

For example, if an analyst wishes to estimate the present (2001) value of costs incurred in year 2002 with an annual seven percent discount rate, he or she would multiply the costs in the year 2002 by 0.93 (the weighting factor for one year at seven percent) to determine the 2001 equivalent.[28]

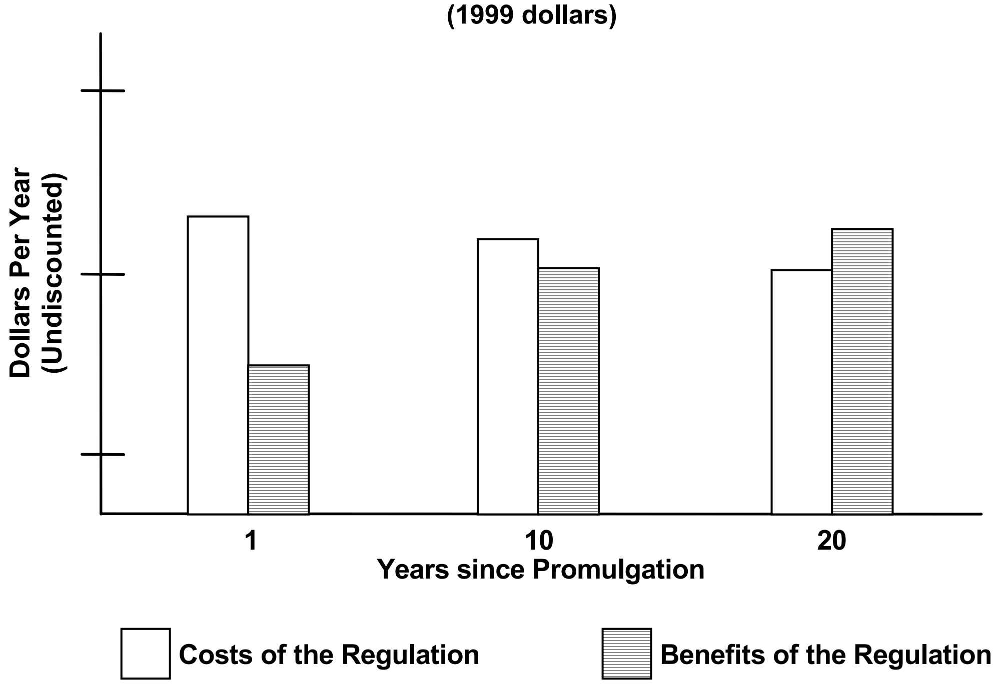
Both OMB and EPA require that economic analyses discount future costs and benefits to a present value equivalent when presenting the results. While concept of discounting is relatively straightforward, much controversy surrounds the choice of an appropriate discount rate. OMB and EPA currently recommend use of a seven percent discount rate, which "approximates the marginal pretax rate of return on an

[28] Most financial calculators and spreadsheet packages contain the formula for estimating these values, which is expressed as: Net Present Value = $NB_0 + d_1NB_1 + d_2NB_2 + ... + d_nNB_n$, where NB_t is the net difference between benefits and costs that accrue in time period *t* (e.g., 0,1,2...*n*), and *n* is the final period for which the analyst has estimated benefits and costs. The discounting weights (d) are determined by $d_t = 1/(1+r)^t$ where *r* is the discount rate and *t* is the time period (or number of years from the present).

average investment in the private sector in recent years," unless a different rate is clearly justified.[29] This rate essentially assumes that government programs are displacing private investment. EPA suggests that analysts also present the results using a rate of two to three percent, which represents the consumption rate of interest, as discussed in more detail in the EPA *Guidelines for Preparing Economic Analyses.*[30] This rate essentially assumes that the programs are using funds that would otherwise be expended on current consumption. These are "real" discount rates; i.e., net of inflation. Any inflation adjustments needed to bring cost and benefit estimates into the same year are made prior to discounting. Regardless of the discount rate chosen, analysts use the same rate for both the cost and benefit analysis to ensure comparability.

Both OMB and EPA also recommend that analysts present the undiscounted stream of costs and benefits over time. Exhibit 5-7 presents an example of this type of graphic.

Exhibit 5-7
Example of Distribution of Costs and Benefits Over Time
(1999 dollars)



Note: Nonmonetized costs and benefits should be identified in the notes on the exhibit.

[29] U.S. Office of Management and Budget, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,* October 29, 1992, p. 9.

[30] This suggestion is echoed in the OMB Guidance, which discusses the use of a three percent rate.

5.3.2 Other Issues

In addition to discounting and inflation, there are several other cross-cutting issues analysts address in both the cost and benefits analyses. We provide a brief overview of these issues below; more information on many of these topics is provided in EPA's *Guidelines for Preparing Economic Analysis.*

Establishing a Baseline. The "baseline" in regulatory analysis refers to conditions now and in the future in the absence of the regulation. The effects of the regulatory options are then compared to this baseline to determine the costs and benefits of each option. Correct specification of the baseline is needed to accurately capture the effects of the regulation; for example, a baseline that exaggerates the deleterious effects of contaminants on the environment without the regulation may overstate the benefits of the regulation, and vice versa. A consistent baseline definition is used in both the cost and benefit analyses to ensure comparable results.

Rule Sequencing. When establishing the baseline conditions from which to assess the benefits of a regulation, another key issue is the sequencing of new regulations. EPA analyses generally assume that the baseline includes the effects of all rules that have been promulgated to date, but do not anticipate the implementation of new rules. However, in cases where several rules with interactive effects are being promulgated jointly, analysts may assess the combined effects of the rules as well as each rule's individual impact.

Risk Trade-Offs: In some cases, techniques to control contamination levels will produce risks. For example, disinfection techniques to control microbial contaminants may create disinfection by-products that pose other risks to human health. Both increases and decreases in various risks may be assessed and presented.[31]

Co-occurring Contaminants: SDWA explicitly requires that analysts consider the effects of co-occurring contaminants [(SDWA, Section 1412(b)(3)(c)(i))]. This issue refers to cases where treatment used to achieve the MCL under consideration also reduces the concentrations of other contaminants. The effects of reducing other contaminant concentrations should be assessed and presented with the overall results. Note, however, that because control of these other contaminants is not required by the regulation, related benefits are generally discussed separately from the benefits

[31] This discussion refers to direct impacts of the regulations on risks. Economists debate whether the effects of regulatory costs on the resources available for other risk-reducing activities (such as health care) are significant and warrant inclusion in these types of analyses. See, for example, Viscusi, W.K., ed., "The Mortality Costs of Regulatory Expenditures," *Journal of Risk and Uncertainty,* Vol. 8, No. 1, 1994 (a special issue devoted to this topic).

associated directly with the MCL, so that decision-makers can consider these impacts independently. This approach is used because the MCL does not require system operators to achieve and maintain the assumed level of removal for the co-occurring contaminants. For example, the level of control of co-occurring contaminants may decrease over time if new treatment techniques are implemented that only target the contaminants for which MCLs are established.

Double-Counting. Throughout the entire analysis, it is important to assess and minimize the extent of double-counting in the benefit and cost estimates. For example, if a rule results in reduced corrosion of water system pipes, it could be assessed as a benefit to the rule. The cost analysis, however, could also assess this impact as a cost savings, resulting in double-counting. In addition, combining certain benefit valuation methods will also lead to double-counting. For example, a property value study may reflect perceived health risks as well as other factors, overlapping with more direct estimates of the value of risk reductions.

Comparing Costs and Benefits. While SDWA requires an assessment of benefits and costs, it does not require EPA to base decisions solely on quantified effects. Rather, it indicates that the quantified and non-quantified benefits must be considered and compared to the costs of the MCL [(SDWA Section 1412(b)(3)(c)(i)]. In many cases, regulatory analyses may include qualitative information for consideration by decision-makers, or may include information on physical effects but no dollar values. In these cases, techniques such as cost-effectiveness analysis or break-even analysis may be used to inform related policy decisions. In a case where the quantified benefits are less than the costs, decision-makers consider whether it is likely that the non-quantified benefits would bridge the gap between costs and benefits, or vice-versa.

These and other issues mean that benefits analysts generally work closely with other members of the regulatory development team. Coordination is needed to ensure that both the cost and the benefit analyses use consistent assumptions regarding baseline conditions and the effects of different regulatory options. In addition, both cost and benefits analysts need to ensure that they address the issues of concern to work group members, senior EPA managers, and stakeholders. Information from the cost analysis is also required for the analysis of benefits, such as data on the population served by systems likely to be affected by the potential regulatory requirements. Successful efforts often involve weekly or more frequent conversations among lead analysts and regulation managers to discuss the implications of preliminary findings and changes in the options under consideration, supplemented by more formal periodic meetings to report on progress and discuss next steps.