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LIST OF ABBREVIATIONS

AI	Adaptive Implementation
AR	Antidegradation reviews
AWQC	Ambient Water Quality Criteria
BCA	Benefit-cost analysis
BOD	Biochemical oxygen demand
BUVD	Beneficial Use Values Database
CCMP	National Estuary Program Comprehensive Conservation and Management Plan
CSO	Combined sewer overflow
CV	Contingent valuation
CWA	Clean Water Act
DELEP	Delaware Estuary Program
DEP	Department of Environmental Protection
DEQ	Wyoming Department of Environmental Quality
DO	Dissolved oxygen
ERA	Ecological risk assessment
EVRI	Environmental Valuation Reference Inventory
FERC	Federal Energy Regulation Commission
FIA	Financial impact analysis
GEAEs	Generic ecological assessment endpoints
GIS	Geographic information systems
HQW	High quality water
NRC	National Research Council
NYDEC	New York Department of Environmental Control
OWRB	Oklahoma Water Resources Board
POTW	Publicly-owned treatment works
ppm	Parts per million
SAR	Santa Ana River
SPDES	State Pollutant Discharge Elimination System

LIST OF ABBREVIATIONS cont.

TDS	Total dissolved solids
TMDL	Total Maximum Daily Load
UAA	Use attainability analysis
WERF	Water Environment Research Foundation
WQS	Water quality standards
WTP	Willingness to pay
WWTP	Waste water treatment plant

PREFACE

Section 303(c) of the Clean Water Act (CWA) requires states and tribes to adopt water quality standards; this includes setting designated uses or goals for their water bodies. In certain cases, use attainment decisions, such as whether or not to change the use of a water body, can be complex because they can lead to gains and losses among health, ecological, institutional, and economic considerations. Estimating the gains from use attainment is not required by the CWA or Water Quality Standards regulation, but evaluating community preferences for water quality against the costs may aid in conducting a balanced analysis. The National Center for Environmental Assessment (NCEA) and RTI International[1] have prepared this report to help water quality officials and the public understand how the assessment of ecological benefits could help support their decisions.

To guarantee a useful product, 20 experts were invited to a workshop held on November 14-15, 2006, in Cincinnati, OH. The objectives of the two-day workshop were to (1) critically examine and develop recommendations for revising an earlier draft of this report (Chapters 1 through 4), (2) employ hypothetical case studies of use attainment problems to evaluate a draft decision process and (3) hold discussions with practitioners and stakeholders to develop recommendations for incorporating community preferences into water quality management decisions. The report has been revised based on the comments from the workshop and it now includes the final chapter developed from the recommendations of the workshop participants. It will be useful for water quality officials, watershed managers, and members of stakeholder groups who are interested in weighing the ecological effects in use attainment decisions.

[1] RTI International is a trade name of Research Triangle Institute.

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EXECUTIVE SUMMARY

ES.1. INTRODUCTION

This report will assist states and authorized tribes—and the associated communities—to understand how the assessment of ecological benefits can help to support their water quality decisions while complying with the provisions of the Clean Water Act (CWA). The report is intended to assist water quality officials, watershed managers, members of stakeholder groups, and other interested individuals in fully evaluating ecological and socioeconomic objectives and the gains and losses that often are involved. Under the CWA, states and tribes adopt water quality standards (WQS). This includes setting designated uses or goals for their water bodies. When natural, man-made, or socioeconomic factors preclude the attainment of a designated use, the CWA recognizes that states and tribes must do an evaluation before changes to a designated use can be made.[2] In certain cases, depending on the factor, the evaluation focuses on the costs and impacts (i.e., losses) of achieving the designated use. However, decisions related to changing or attaining designated uses sometimes involve both gains and losses (or benefits and costs) among health, ecological, institutional, and socioeconomic considerations. Evaluating the gains from continuing to attain the current designated use (rather than degrading water quality) may aid in developing a balanced analysis. An important step in achieving this report's goal is integrating the assessment of ecological quality with the assessment of economic considerations so that the benefits and costs can be understood, communicated, and evaluated in the standard-setting process. Therefore, this approach requires evaluating community preferences and Chapter 1 outlines specific situations where this may occur.

The report incorporates methods from ecological risk assessment, stressor identification, economics, and social science to explain how to incorporate this information into water quality attainment decisions. Specific objectives (by chapter) are as follows:

- provide an introduction to the CWA and WQS regulation and analyses related to setting or changing designated uses (Chapter 2)
- create a basis for understanding the relationship between use-attainment decisions and the effects on ecosystems, ecosystem services, and ecological benefits (Chapter 3)

[2] In some cases, these evaluations could establish that a higher use is attainable.

- serve as a reference for methods that elicit or infer preferences for benefits and costs related to attaining uses (Chapter 4), and
- present a process for incorporating new approaches in water quality decisions (Chapter 5).

Chapter 1 also introduces the general decision framework for addressing WQS and use-attainment issues (Figure ES-1). It describes a series of steps for framing the decision problem and then comparing the advantages and disadvantages of different management options. It also identifies the points in the process where input from the community and the assessment of community preferences can be used to strengthen the decision process. Chapter 1 also describes how Figure ES-1 is used as an organizing framework for this report, and it discusses how each chapter relates to the diagram.

ES.2. UNDERSTANDING THE GROUND RULES: AN INTRODUCTION TO WATER QUALITY STANDARDS, USE ATTAINABILITY ANALYSES, AND ANTIDEGRADATION REVIEWS

Chapter 2 explains how the water quality goals and ecological integrity for a water body, termed its designated uses, are established as part of a WQS program. It discusses the circumstances under which designated uses or water quality goals can be changed, with a focus on the important role of socioeconomic analyses in making better decisions.

The purpose of the WQS program is to protect public health and welfare by supporting the objectives of the CWA, which articulates two overarching goals:

- restore and maintain the chemical, physical and biological integrity of the nation's waters.
- achieve a "fishable/swimmable" level of water quality: one that provides for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water, wherever attainable.

To comply with the provisions of the CWA, states and authorized tribes must establish WQS for all water bodies. These standards consist of designated uses, water quality criteria to protect those uses, and an antidegradation policy to maintain high quality waters. General

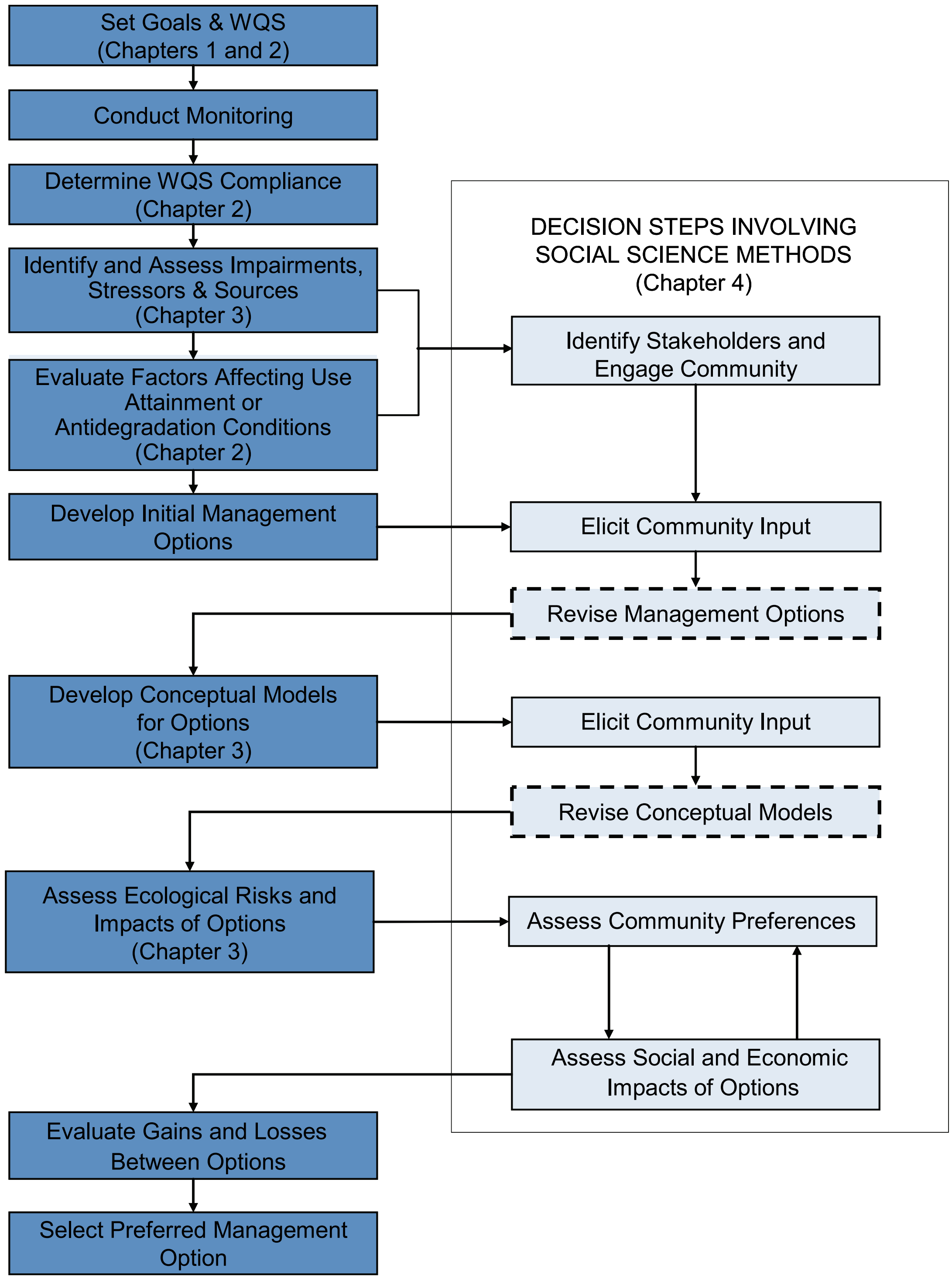

FIGURE ES-1

Framework for Incorporating Community Input and Preferences and Evaluating Ecological and Socioeconomic Gains and Losses in WQS Decisions
(chapter listed provides details of decision step)

provisions, such as variances that temporarily relax a designated use to work toward attainment, may also be included, subject to EPA review and approval.

States and tribes must conduct use attainability analyses (UAAs) to justify specific designated use modifications for water bodies. A UAA is a structured scientific assessment of the factors affecting the attainment of a use. These factors can include a range of naturally occurring, human-caused, physical conditions, or economic and social impacts. The majority of UAAs rely on noneconomic arguments, but economics may play a determining role in some cases. An economic UAA must demonstrate that the controls required to attain the use would result in "substantial and widespread economic and social impact."

In contrast to UAAs, antidegradation reviews tend to place more emphasis on economic considerations. Antidegradation reviews examine whether water quality in "high-quality" waters may be lowered if it is necessary to permit "important economic and social development" as long as existing[3] and "fishable/swimmable" uses are not impaired.

To provide states and tribes with guidance on using economic analysis in UAAs and antidegradation reviews, EPA compiled the *Interim Economic Guidance for Water Quality Standards: Workbook* (U.S. EPA, 1995). To understand the current practices based on the *Interim Economic Guidance*, a literature search was conducted, which identified 13 UAAs and four antidegradation reviews that incorporate economic arguments. One conclusion from the available case studies is that, to the extent that an economic analysis is done, most attention is given to costs data of attaining designated uses or of maintaining high water quality. Very little attention is given to the economic benefits that would be obtained from use attainment or of maintaining high water quality. Therefore, the analyses, while useful for regulatory determinations, may not fully inform affected communities about the benefits and effects of these decisions on their well-being. For example, in the UAA case, a community may ask, what are the benefits of attaining a designated use that is not currently being attained? Or, in the antidegradation review case, the relevant question might be, if we allow the degradation being considered, what are the damages produced? The answers to these questions may lead to a community's reconsideration of whether a use change (and hence, the quality of their water) is needed.

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[3]The WQS regulation defines existing uses as those uses "actually attained in the water body on or after November 28, 1975, whether or not they are actually included in the water quality standards" (40 CFR 131.3 (e)).

ES.3. UNDERSTANDING THE CHOICES: RELATING WATER QUALITY MANAGEMENT DECISIONS TO CHANGES IN ECOSYSTEMS, ECOSYSTEM SERVICES, AND ECOLOGICAL BENEFITS

Although existing WQS guidance for evaluating socioeconomic impacts in UAAs and antidegradation reviews focuses on financial and regional economic impacts, many states, tribes, and communities could take a broader approach in analyzing the effects of selecting different water quality management options. Chapter 3 provides decision-makers with a framework for understanding how these different options can affect ecosystems and human well-being. This framework adapts and extends concepts from ecological risk assessment to show how aquatic ecosystems are linked to and support humans through the provision of "ecosystem services." It also describes how these services are related to designated uses. The framework is further described through a series of "expanded conceptual models," which are applied and illustrated in five case studies, focusing on different water quality management decisions.

Figure ES-1 also conveys the relationship of stressor identification and ecological risk assessment to the other components of use-attainment decisions. When designated uses are not attained because WQS are not being met, the water body is said to be impaired. Stressor identification can identify the causes of impairment, allowing management alternatives to be developed (U.S. EPA, 2000). So together, ecological risk assessment, stressor identification, and economic analysis can provide a means to better characterize ecosystem services and compare the management alternatives of use-attainment decisions.

The concept of ecosystem services is fundamental for evaluating how humans are supported by ecological systems and how their well-being is affected by changes in these systems. This report adopts the following definition (U.S. EPA, 2006):

> **Ecosystem services** are outputs of ecological functions or processes that directly or indirectly contribute to social welfare or have the potential to do so in the future. Some may be bought and sold, but most are not marketed.

The definition above highlights the importance of understanding the relationship between ecosystem services and designated uses. In essence, these terms represent two distinct but related ways of characterizing how the quality or conditions of water resources support human well-being. When water quality management decisions result in changes to designated uses, they are also likely to affect the types and levels of ecosystem services that the water resource provides. However, changes in ecosystem services may occur even if use attainment does not change.

Conceptual models expressed as flow diagrams are particularly useful tools for representing relationships within and between ecological and human systems. For example, these diagrams play an integral role in ecological risk assessment by illustrating relationships between sources of stressors (e.g., abandoned mines producing acid mine drainage), ecological entities, and their responses to the stressors. Chapter 3 presents conceptual models to evaluate the broader societal implications and the gains and losses associated with setting or modifying WQS.

Figure ES-2 shows that land uses or human activities and other sources are capable of introducing stressors to aquatic ecosystems. These stressors disrupt the normal functioning of the ecosystem, which can cause reductions in water quality and can impair the ecosystem's ability to provide key services. However, these same sources and land uses are also capable of providing other important goods and services to humans. For example, agricultural land uses may degrade water quality in local streams while at the same time providing valued food crops for consumers.

Figure ES-2 also illustrates how management options considered in a standard-setting process, such as restoring a riparian area, will typically alter the effects of land uses their ability to support or sustain human well-being. Because humans may experience both gains and losses as a result of these options (shown by purple lines), the figure also demonstrates the gains and losses inherent with these types of decisions. By controlling stressors to the aquatic ecosystem (represented by the blue lines), a management option should improve certain ecosystem services, resulting in gains to individuals who value these services. At the same time, however, the costs of controlling stressors impose losses on certain individuals.

It also shows how the attainment of designated uses fits into the conceptual model framework. Use attainment is ultimately determined by comparing observed water quality (or related conditions) in the aquatic ecosystem with the relevant water quality criteria.

Chapter 3 describes specific steps for developing these expanded conceptual models. Using the framework outlined in Figure ES-2, the chapter illustrates the development of expanded conceptual models through five hypothetical "case studies," which address the following types of WQS scenarios:

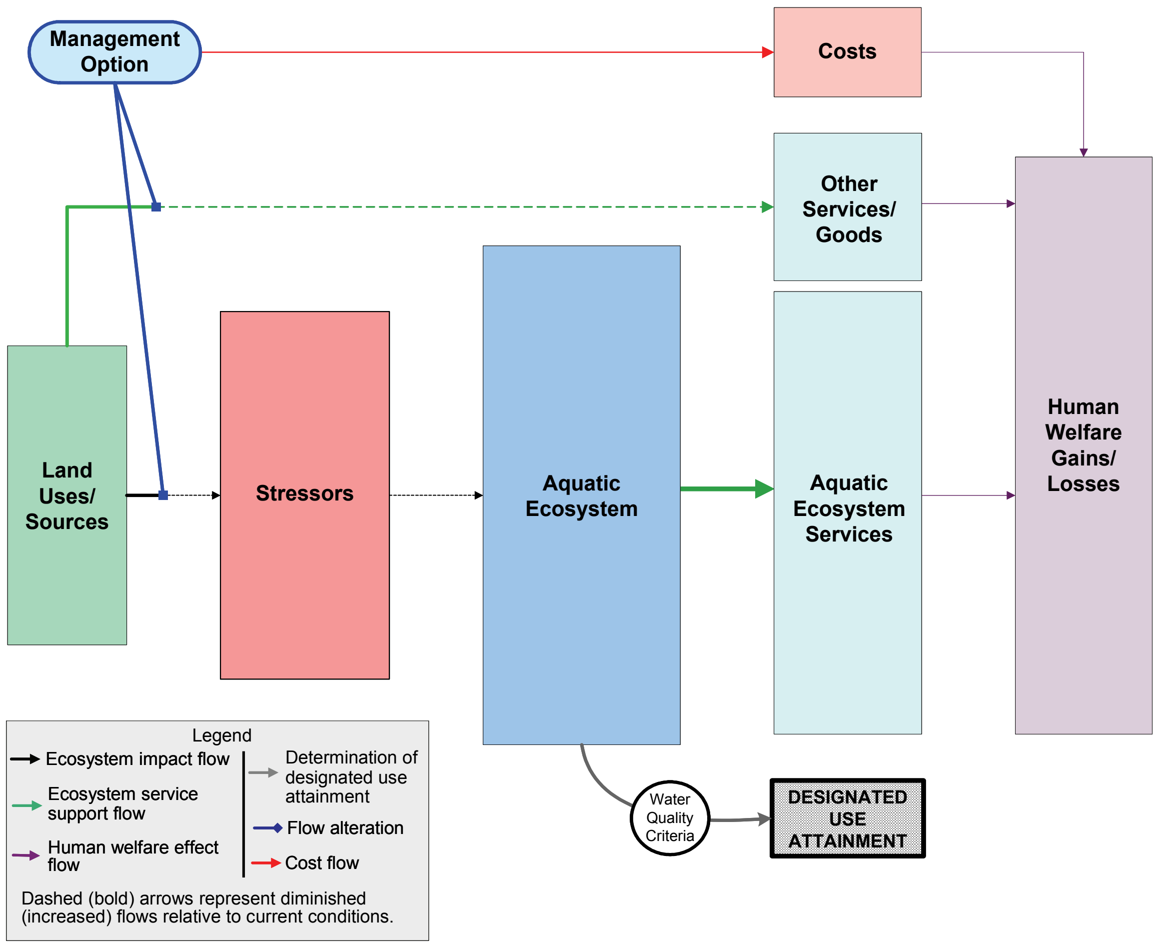

FIGURE ES-2

Effects of Management Options on Aquatic Ecosystem Services and Human Well-Being

- Case Study 1 presents a hypothetical UAA addressing acid mine drainage (AMD) impacts on a tributary stream and a river.
- Case Study 2 presents a hypothetical UAA addressing combined sewer overflows (CSOs) and stormwater impacts on a river system.
- Case Study 3 presents a hypothetical UAA addressing agricultural impacts on an intermittent stream.
- Case Study 4 presents a hypothetical antidegradation review of a proposed retail development complex.
- Case Study 5 presents a hypothetical UAA addressing discharges to an effluent-dominated stream.

ES.4. UNDERSTANDING THE TOOLS: A SUMMARY OF METHODS FOR CHARACTERIZING THE GAINS AND LOSSES

Chapter 4 describes and compares various methods—broadly defined as "social science methods"—that can be used to inform the decision-making process for WQS. A common goal of these methods is to help decision-makers understand the perceptions, attitudes, objectives, and preferences of relevant stakeholders in an affected community and to apply this information to improve policy decisions (e.g., those affecting water quality). The purpose of Chapter 4 is to provide an overview of these methods and a basic understanding of their relative advantages and disadvantages. Rather than providing detailed instructions on how to apply each method, the chapter is intended to help the reader gauge which methods might be applicable to his or her situation on a case-by-case basis.

The overall goal of the proposed decision-making process described previously in Figure ES-1 is to select the management option that meets the highest attainable use of a particular water body or segment and best addresses the needs and priorities of the affected community. Throughout this process, social science methods can be used to address three supporting objectives:

1. involve the community in framing the key elements of the WQS decision,
2. assess community preferences for different management options to meet the highest attainable use and
3. assess the expected social and economic impacts of the different options.

Chapter 4 discusses the types of social science methods that are best suited to addressing each of these objectives. It divides these assessment methods into two main categories: sociocultural and economic methods.

Sociocultural methods provide a number of alternative perspectives and approaches for eliciting, evaluating, and applying community preferences and stakeholder input in the decision-making process. These methods can be broadly categorized as either deliberative or analytic methods (and in some cases both). In deliberative methods, groups of stakeholders are convened to discuss and collectively assess possible decisions (e.g., those related to water quality). In addition to providing structured approaches for eliciting community input on technical matters, deliberative methods can be used to elicit and assess community preferences for management options. They also offer the advantage of encouraging active community involvement throughout the decision-making process. In analytic methods, data on community preferences are analyzed by decision-makers without necessarily engaging in dialogue with stakeholders. These methods have the advantage of providing decision-makers with a rigorous and structured set of responses on which they can base their selection of the final WQS management option. Some researchers have advocated decision-making processes that incorporate both deliberative and analytic components into socioeconomic assessments. Chapter 4 identifies and describes 13 specific sociocultural methods and distinguishes them according to whether they are primarily analytic or deliberative methods (or both).

In contrast to sociocultural methods, economic assessment methods share a common conceptual framework, which guides how preferences are interpreted, quantified (typically in monetary terms), and used to compare and evaluate options (e.g., through benefit-cost or cost-effectiveness comparisons). Chapter 4 identifies and describes nine commonly used economic assessment methods.

Economic analyses of environmental regulations and related policies are geared toward understanding how society's resources, including its natural resources like water, are used or exchanged as a result of policy actions and how human well-being may be affected. Two commonly used criteria in economic analyses for determining whether society is better off as a result of a policy are *efficiency* and *equity*. The main questions underlying the efficiency criterion are whether and to what extent the gains to society (benefits) exceed the losses to society (costs) from a given policy. This criterion is the basis for benefit-cost analysis, which is a widely used economic analysis method that involves identifying, quantifying, and valuing the positive and negative impacts on society's well-being that result from policy changes. The main questions underlying the equity criterion have to do with how the gains and losses are distributed across society. In contrast to the efficiency criterion, there is no generally agreed upon measure or assessment method for gauging equity. Nevertheless, the process of developing and conducting benefit-cost analysis often requires the separate estimation of different types and sources of benefits and costs, which, in turn, can also be useful for informing equity concerns.

One of the main challenges in applying benefit-cost analysis to evaluate environmental policies related to meeting WQS is that it requires methods for expressing human welfare changes in monetary terms. In certain instances, such as adding new pollution control that reduces profit and gets passed on to consumers as price increases, this process is relatively straightforward because the changes are experienced by humans as monetary gains or losses.

In other instances, welfare changes are not directly associated with monetary gains or losses, for example, benefits from improved recreational opportunities at a water body. In these cases, economists and other practitioners of benefit-cost analysis generally regard "willingness to pay" (WTP) as the conceptually correct measure for valuing changes in individuals' welfare.[4] For example, if changes in water quality improve fishing conditions at a lake, the benefit to anglers can be expressed as the maximum amount they would have been willing to pay for the change.

All the methods discussed in Chapter 4 require data collection regarding the affected community. These methods are broadly categorized as either primary or secondary data collection. Primary data collection entails gathering original data directly from community members or stakeholders. Among the more commonly used methods are individual interviews, surveys, group deliberations, and observation. Secondary data collection relies on existing sources of data, many of which can be used to support and conduct socioeconomic assessments. For example, data collected by the Bureau of Census, including information on population, housing, and economic characteristics, can be useful for identifying and characterizing the potentially affected community.

[4] Willingness to accept (WTA) is the minimum amount an individual is willing to accept to forego the change. Both WTA and WTP are correct measures for valuing changes. However, to simplify, we only use WTP in this report. Freeman (1993) provides information on the differences between WTA and WTP and how to choose the appropriate measure.

Chapter 4 compares 22 different social science methods according to the data collection technique most commonly used for the method. Using a 5-point scale from very low to very high, each method is also rated by cost/complexity which refers to the costliness and/or complexity of method, in terms of time, data, and specialized technical skills required to implement the method.

ES.5. WORKING THE PROCESS: BUILDING AN APPROACH FOR COMMUNITIES TO UNDERSTAND THE ECOLOGICAL RISKS, COSTS, AND BENEFITS OF WATER QUALITY MANAGEMENT DECISIONS

The purpose of Chapter 5 is to provide a more detailed description of how the proposed decision process outlined in Figure ES-1 can be implemented in practice. The chapter is organized according to three main phases of the process: (1) framing the WQS decision, (2) comparing the advantages and disadvantages of the different management options, and (3) making the decision (selecting the option). In each case, it describes the main components of the decision process and the techniques that can be used to address each component. It also uses two of the hypothetical case studies described in Chapter 3—the CSO example and the AMD example—to illustrate specifically how the methods and tools described in the previous chapters can be applied to inform and strengthen each stage of the decision-making process.

Framing the WQS decision involves identifying the key water quality impairments, along with the related sources and stressors, and determining the set of feasible options available for addressing the impairment. It also means recognizing and engaging community residents in initial discussions of how they are likely to be affected by both the impaired water and the options available for addressing the impairment. Chapter 5 describes how group deliberative methods can be used in several ways to involve the community in framing the decisions, including (1) identifying community priorities, concerns, and constraints; (2) revising and defining the most practical set of management options and (3) revising and finalizing conceptual models that illustrate the key linkages between environmental conditions and human welfare and the gains and losses involved in the decision-making process. In particular, it describes how deliberative processes could be used to develop conceptual models incrementally and how simplified versions of the models might be used to communicate the decision problem to community residents.

Assessing community preferences entails gathering information to determine how different segments of the affected population regard and value different features of the WQS management options. With this information and with an understanding of the expected ecological impacts of different options (e.g., through ecological risk assessment), it is then possible to estimate the social and economic impacts of the different options. Regardless of how they are organized, the purpose of all these activities—ecological risk assessment, preference assessment, and the assessment of economic and social impacts—is to acquire and organize information that can be used to better evaluate the gains and losses between the options. Chapter 5 describes how social science methods can be used to evaluate gains and losses by collecting both qualitative and quantitative information on preferences and impacts. It also explains how these and other methods can be applied to analyze the equity implications of different management options.

The final step, as defined in Figure ES-1, is for the decision-makers to select the management option that best addresses the need to protect human health and the environment, the communities' needs, and compliance with the CWA and WQS regulation to attain the designated uses. Chapter 5 emphasizes that the purpose of this report is not to suggest the criteria that should be used in making any particular decision, rather to propose methods that could help decision-makers better frame and evaluate the options. None of the individual methods described in the report can determine unequivocally which management option is best suited to address a particular WQS issue. However, they should enable communities and water quality managers to better understand the ecological and socioeconomic gains and losses involved, and therefore, promote better environmental and economic decisions.

ES.6. REFERENCES

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