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**Natural
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National Resource Economics Handbook

Part 612 Water Quality

Issued December 1995

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(200-vi, NREH, December 1995)

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Part 612 Water Quality
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Chapter 1 Introduction

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Chapter 1 Introduction

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Chapter 1 Introduction

612.0100 Purpose

This document's purpose is to guide Natural Resources Conservation Service (NRCS), formerly Soil Conservation Service, personnel on the evaluation of economic benefits of measures that reduce water pollution from nonpoint sources. Exhibit A provides the policy basis for this part of the National Resource Economics Handbook (NREH). Economic analysis of nonpoint source control includes evaluation of offsite costs and benefits as well as those occurring onsite. Benefits from water quality improvements result from increased or more highly valued usage of the better quality water resources. Avoided damages and avoided mitigation expenses are also benefits.

This handbook is intended to be used with other Natural Resources Conservation Service references, such as the Field Office Technical Guide, National Watershed Manual, National Planning Procedures Handbook, Water Quality Field Guide, Water Quality Indicators Guide: Surface Waters, National Engineering Handbook, National Sociological Manual, Economics Handbook, and Agricultural Waste Management Field Handbook. It is meant to supplement the Water Resources Council Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, generally referred to as Principles and Guidelines. The NTC technical notes referred to in this handbook are available in many state offices and from the NRCS National Office in Washington, DC. The Economics Handbook cited throughout this part of the NREH is in draft and copies of the parts cited are available in most state offices and at the NRCS National Office.

Related technical guidance is in Midwest NTC Technical Note 190-L1-5, Project Planning for Water Quality (Decenber 1987); Tech Release S8, General Guidelines for the Assessment of Water Quality (June 1976); and SNTC Technical Note 1706, Project Planning for Water Quality Concerns (November 1992).

612.0101 Scope

This handbook addresses economic benefits of measures that reduce water pollution from nonpoint sources. The treatment of risk is discussed, but comprehensive risk analysis guidelines are beyond this guide's scope. Land treatment and other conservation measures cost computations are covered in the draft of Part 630, Watershed Planning, Economics Handbook, and in the National Watershed Manual.

612.0102 Evaluation criteria

(a) Benefit-cost analysis

The first issue in analyzing benefits of nonpoint source pollution control is to link source control to resulting benefits (cause and effect). The value of source control can be estimated only in relation to impacts having benefits or reducing damages. Modeling the linkages to benefits involves several disciplines, such as hydrology, geology, soil science, environmental science and engineering, and biology. This interdisciplinary process and the economist's part in it are described further in Chapter 3, Quantifiable Impacts.

When impacts are traced, the value of pollutant reduction differs greatly depending on proximity to a water body, alternative uses of the affected water, and time lags before the benefits occur. It is incorrect to assign the same dollar value per ton of reduced pollutant if the impacts per ton differ.

The second issue in analyzing benefits of nonpoint source pollution control is quantifying benefits. Consumer and producer surplus provide the conceptual basis for measuring economic benefits.

In many cases the benefits estimates are uncertain. The uncertainties should be reported.

The impacts of a project having water quality effects are displayed in the context of the four accounts: National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). When economic estimates of environmental quality impacts are available and of sufficient quality, they are customarily reported in the NED account. Section 1.7 of Principles and Guidelines describes in which account various types of impacts should be reported.

Benefit-cost analysis requires accounting for the time value of money. It also shows the benefits and costs for each year of project life, the net present value, and the average annual equivalent. (See the draft section 620.30, Economics Handbook, or a text such as Gittinger 1982.)

(b) Cost-effectiveness analysis

Sometimes benefits cannot be expressed in monetary terms. If the same benefits are produced by each alternative, then cost-effectiveness analysis is acceptable. For example, if the goal is to protect X amount of eagle habitat, the plan that protects X amount of eagle habitat at the lowest overall cost should be chosen.

Exhibit B in this part of the NREH gives an example of least cost analysis to choose between resource management systems. The draft Part 622, Conservation Options Procedure Example, of the Economics Handbook demonstrates the use of cost-effectiveness analysis to evaluate resource conservation options.

(c) Threshold levels

Water quality is defined in terms of its fitness for particular uses (fishable, swimmable). Overly high levels of some contaminants prohibit some uses. The level of a contaminant that, if exceeded, precludes a particular use is the contaminant's threshold level for that use. Threshold levels also apply to parameters other than contaminants, such as water temperature.

An example of threshold levels would be if high fecal coliform counts closed a stream to water contact recreation. The least cost combination of practices that would reduce fecal coliform levels to an acceptable level could consist of an animal waste management system, buffer strips, and fencing and pasture improvements. No water contact recreation benefits occur until the pollutant is reduced to or below the threshold limit.

An exception on how to treat threshold levels occurs in big basin problems if a package of projects will bring the system up to the needed quality. In that case one assigns a share of eventual benefits to each project that is part of the larger clean-up effort. For example, if a project on Watershed A contributes 10 percent of the reduction in pollutants that a system of projects will achieve, it would be acceptable to assign it 10 percent of the benefits from the overall cleanup plan.

(d) Planning steps

Water quality problems should be approached with the planning steps outlined in the National Planning Procedures Handbook (Part 600.2). The future projected with the project should be compared to the future projected without the project. Midwest NTC Technical Note, Project Planning for Water Quality, Series 190-LI-5 (December 1987) and the South NTC Technical Note 1706, Project Planning for Water Quality Concerns (November 1992) give further information.

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National Resource Economics Handbook

Chapter 2 Economic Concepts

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Chapter 2 Economic Concepts

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Chapter 2 Economic Concepts

612.0200 Introduction

This chapter provides an overview of the economic concepts used in water quality analysis.

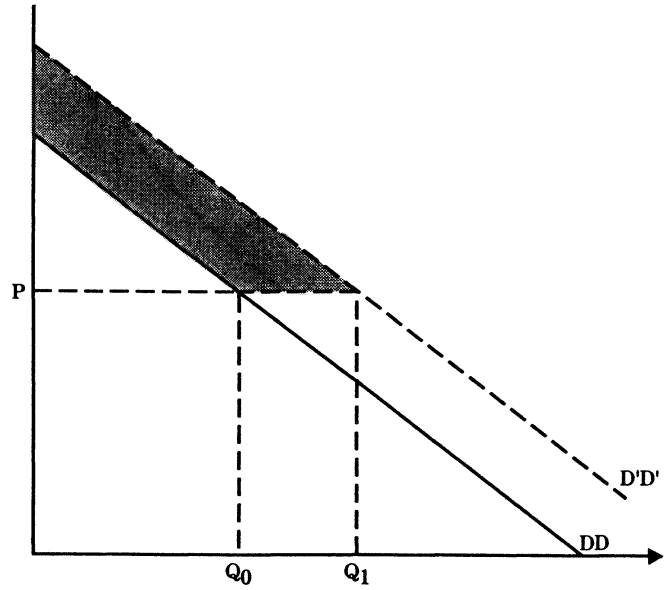
612.0201 Benefit measures: consumer and producer surplus

(a) Consumer surplus and water quality

Consumer surplus can be estimated when demand is known. To estimate consumer demand for a good that is not traded in a market, such techniques as the Travel Cost Method or Contingent Valuation Method need to be used to infer demand and calculate values to estimate consumer surplus. See part 612.0403(c) of this handbook for information on non-market valuation techniques.

Figure 2–1 (curve DD) shows an individual's demand curve for number of days swimming at a beach. A water quality improvement could shift the demand curve to the right. The increase in consumer surplus is shown by the shaded area.

Figure 2–1 Consumer surplus



A water quality improvement shifts the demand for days swimming at the beach to the right. The increase in consumer surplus is shown by the shaded area. In this example, the consumer's opportunity cost of a beach day is a constant, P.

The gross benefits to consumers from an improvement in water quality is the sum of consumer willingness to pay for the improvement. Consumer surplus is the amount by which the consumers' willingness-to-pay exceeds what they must pay (taxes, user fees) to get the improvement.

(b) Producer surplus and water quality

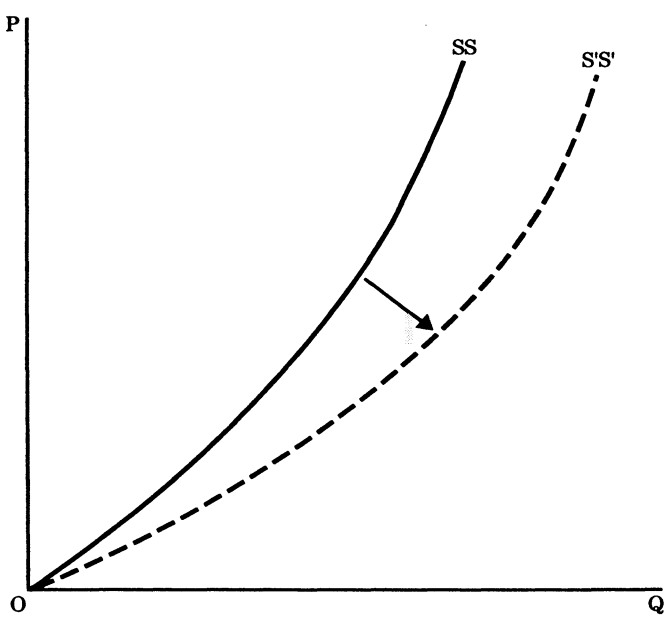
Producer surplus is the difference between the cost of production and the sale price. The supply curve SS in figure 2–2 represents the marginal cost of producing each successive unit of a good.

Sometimes, improvements to water quality may reduce producer costs. For example, costs to treat cleaner water for use in manufacturing processes could be less than the cost before a water quality improvement. A decrease in producer costs from a water quality improvement is illustrated by Curve S'S' in figure 2–2. Example 5–2 in Chapter 5, Benefit Categories, illustrates input cost-savings from improved water quality.

The shaded area in figure 2–3 shows the increase in producer surplus from lower input costs. In this case a producer is better off after nonpoint source pollution controls have been implemented.

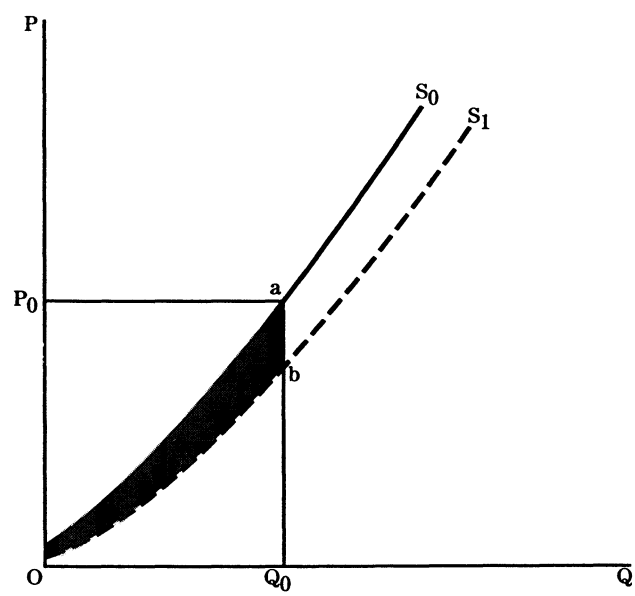
Water quality improvement effects on producer income should be added to the consumer surplus to find the total net benefits.

Figure 2–2 Reduction in input costs



Improvements in water quality may reduce costs of production. When input costs fall, the supply curve shifts downward. For example, the cost of producing 100 pounds of beef is lower when the cattle are not stressed by a poor quality water supply.

Figure 2–3 Change in producer surplus



If production costs fall and the producer continues to sell Q_0 units at P_0, producer surplus increases by area Oab. In this example, production quantity is fixed in the short run and the producer is a price taker.

612.0202 Distribution of benefits and costs and technology adoption

When evaluating whether to proceed with a public project, all members of society are considered and all associated costs and benefits need to be weighed. However, technology adoption generally does not occur on a voluntary basis if the costs to the individual whose practices must change exceed that individual's benefits.

A shift to conservation systems may be socially worthwhile, but not economically viable for the private decisionmaker. Economists should recognize cost-sharing arrangements that can facilitate the desired social objectives without unduly burdening particular individuals.

Sometimes participation rates can be predicted with econometric technology adoption models. Sociological factors in technology adoption and diffusion are described in Nowak (1992) and Nowak and O'Keefe (1992). South NTC Tech Note 1801, Guide for Estimating Participation in Conservation Operations and Watershed Protection Projects (February 1989) gives additional information. Holding forums to ask the people involved also works well.

612.0203 Incremental analysis

Costs, physical effects, and benefits should be associated with each increment to the extent possible. Incremental analysis is to be used for each evaluation unit and the separable increments of the recommended plan. In watershed plans, incremental analyses must be shown in the Investigation and Analyses Report (National Watershed Manual, part 504.43).

Part 620.12 of the Economics Handbook (in draft) gives details about incremental analysis. Procedures for incremental cost analysis are also given in the Corps of Engineers documents, Economic and Environmental Considerations for Incremental Cost Analysis in Mitigation Planning and Cost-Effectiveness Analysis for Environmental Planning: Nine Easy Steps.

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Chapter 3 Quantifiable Impacts

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Chapter 3 Quantifiable Impacts

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Chapter 3 Quantifiable Impacts

612.0300 Introduction

To have measurable economic offsite impacts from conservation practices, an improvement in water quality caused by implementation of the practices must have occurred. Furthermore, these water quality improvements must enhance the value of the water resource.

612.0301 Water quality indicators

Many factors determine whether water quality is adequate for a specific use. These factors include type and quantity of pollutants, bacterial levels, requirements for designated uses, and such variables as streamflow, dissolved oxygen levels, temperature, pH levels, and aquatic habitat suitability. The term *water quality indicators* will be used in accordance with Principles and Guidelines to refer to factors that influence the suitability of water quality to a particular use.

A brief overview of water quality impairments and agricultural land use factors follows. Refer to the Water Quality Field Guide for information on the type and extent of impairment typically arising from each agricultural activity. The Field Office Technical Guide (FOTG) section III defines important water quality concerns.

Indications of poor surface water quality and factors that are frequently the causes include:

- Excessive algae growth—Measured by a chlorophyll "a" test and often caused by excess nutrients, such as nitrates and phosphates, entering a water body.
- Bacterial contamination—Frequently caused by untreated fecal matter.
- Sedimentation—Measured by lake clarity, turbidity, or Secchi Disk and often caused by excess erosion from the land.
- Low dissolved oxygen—Measured by BODs or DO tests and often resulting from high oxygen demanding substances, such as biodegradable organic matter, in the water.
- Presence of toxic compounds, such as pesticides, other organics or hydrocarbons, and heavy metals, resulting from their release and persistence in the environment.
- Other chemicals in excess of the assimilative capacity of the water body entering via land, air, or water.

Agricultural management deficiencies that may exacerbate pollution of surface water include:

- lack of erosion control on cropland, pastureland, and other land,
- failure to protect streambanks from animal trampling,
- fertilizer application beyond crop needs,
- poor animal waste management including spreading beyond the capacity of the land to use the nutrients, and
- inadequate animal carcass disposal practices.

Treatment measures that improve these practices improve surface water quality. Land treatment measures, such as filter strips, conservation tillage, pasture management, and animal waste management systems, lessen nonpoint source pollution of surface water. However, the system must be analyzed as a whole. Treatment measures for surface water quality may induce ground water pollution, such as if a dairy waste pond were to pollute an aquifer.

Poor ground water quality is indicated by high nitrate levels and contamination by pesticides, usually in shallow aquifers (less than 100 feet deep). The greatest cost of poor ground water quality is impairment of drinking water supplies. In some cases there can also be impacts associated with migration of the contaminant-laden water into other ecosystems (such as a contaminated spring with an outlet to a lake or stream).

Agricultural management deficiencies that lead to ground water pollution include excessive nitrogen applications, cultivation on extremely sandy soils or areas of limestone geology (sink holes), poor irrigation management, mixing and loading near wellheads without backflow prevention or proper well sealing, and high rates of pesticide application. Treatment measures that address these inappropriate practices will most likely improve ground water quality.

Descriptions of physical baseline and projected conditions need to include information relevant to social implications. Physical impacts perceived by users need to be articulated (e.g., the presence of algae in swimming holes). The economist can identify social implications of the physical impacts if he or she is involved early in the planning process. The other team members need to be aware of the type information required by the economist.

Key water quality economics questions are:

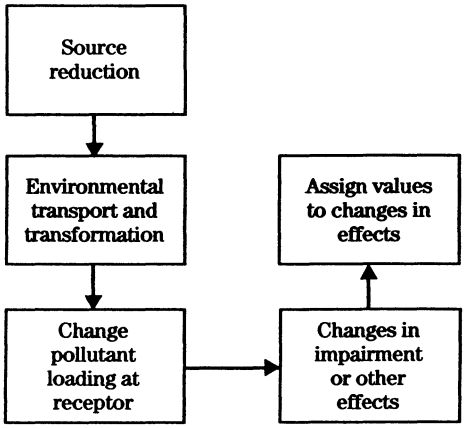
- What uses are impaired, e.g., contact recreation (swimming), noncontact recreation (fishing, boating), aesthetics, water supply (industrial, municipal, agricultural)?
- What ecological functions are impaired, e.g., for plants and animals?
- Who is affected, e.g., which user groups, whose property?
- What contaminants are responsible, e.g., nitrogen, phosphorous, BODs, suspended solids, toxics, volatile organics?
- What are the cause and effect relationships between the contaminants and uses?
- What are the areas of uncertainty?
- What risks do the contaminants pose, e.g., human health, animal health, plant health?
- Where do the contaminants come from and what are their absolute and relative magnitudes? The total pollutant load contribution from all sources should be identified and quantified as best as practicable.
- What are the time lags between implementation of source reduction measures and observation of water quality improvements?
- What other delays having economic consequences are there between treatment and response? (For example, if trees are planted on streambanks to improve stream temperature, there is a delay until the trees become effective and a further lag for fishing to improve.)
- What are "acceptable" (e.g., Federal, State, local criteria) pollutant levels? How much contaminant reduction is necessary to meet this level and to correct the impaired use?
- What are the physical, chemical, and biological changes associated with alternative treatment methods?
- What are the capital and operating and maintenance costs associated with alternative treatment methods?

612.0302 Impacts with economic value

Improvements of surface water quality and ground water quality often result in economic benefits. Water quality degradation has costs associated with impairment of designated uses and of indirect or secondary water uses, such as aesthetics and tourist enterprises. Designated uses of a water body can include agricultural water use, contact (swimming) and noncontact (boating and fishing) recreation, water supply, industrial water use, and other uses.

Figure 3–1 illustrates the cause and effect relationships of a change in water quality. Monetary values may be associated with the first box, source reduction, and the final box, where values are assigned. For example, the costs of a change in tillage practices enters into the economics of source reduction. The tillage practice changes reduce soil erosion and resulting sediment and nutrient loading into a stream system. The physical scientists determine the sediment and nutrient reductions and their effect on fish habitat and populations. They find that fish habitat in the nearby lake improves, which increases fish populations. The social scientists evaluate the lake's recreational use and how it has declined because of reduced fish populations. Increased fish populations caused by water quality improvements allow greater recreational use. The social scientists predict the amount of increased recreational use and estimate its value to society. Also, social scientists evaluate any other uses of the increased fish populations (commercial uses by Native Americans). Thus an interdisciplinary approach to cause and effect relationships is required.

Figure 3–1 From pollution control to economic impact



612.0303 Worksheet to list quantifiable impacts

Example 3–1 is a sample worksheet to list quantifiable impacts. Such worksheets could be developed for each agricultural practice typical of a locality. The worksheet would assist in enumerating onsite and offsite economic impacts before and after changes in management practices. The sample worksheet is for identifying water quality benefits from improved nutrient management for cropland, hay fields, and pasture.

Example 3–1 Sample worksheet—Water quality benefits from improved nutrient management

Describe impairments	Suppose seasonal algal blooms occur in a water body. At low flow conditions, the water is greenish. The quality of the water corresponds to the classification of **fair** (Field Sheet 3A, Water Quality Indicators Guide: Surface Waters). The impairments could include clogged pipes, water supply taste, color or odor, cattle abortion, reduced recreational use, or other impairments (from Field Sheet 3A, Water Quality Indicators Guide: Surface Waters).
Identify the causal links	Are the impairments caused by practices that would changeas a result of a proposed project? If some impairment would not be mitigated because of the project, then no project benefits would be attributable to that use category.
Characterize the options for treatment and/or new management systems	Costs of treatment options would be calculated following the guidelines in Part 630 of the Economics Handbook (in draft).
Describe impacts in quantitative terms	An evaluation of how uncertainties could influence the range of impacts would be included in this description. Impacts would need to be allocated by treatment measure for purposes of incremental analysis.
Enumerate the onsite and offsite benefits	For example, the following onsite and offsite market and non-market impacts may occur from improved nutrient management systems for cropland, hay fields, or pasture.

Example 3–1 Sample worksheet—Water quality benefits from improved nutrient management—continued

Market benefits onsite:

- *Qualitative description of benefits*—Purchases of fertilizer inputs would be reduced. Crop yields may change. Management time may increase. There may be fewer cattle abortions.
- *Estimated value to farmer (onsite stakeholder)*—Estimate cost savings, revenue changes, and the value of changes in time inputs. Estimate value to farmer of reduced cattle abortions.

Market benefits offsite:

- *Identification of affected parties (stakeholders)*—Municipal and industrial water suppliers benefit from the improvement.
- *Qualitative description of benefits*—Intake pipes clog up less.
- *Estimated value (by stakeholder group)*—Estimate cost savings from reduced operation and maintenance costs.

Non-market benefits offsite:

- *Identification of affected parties (stakeholders)*—Recreational anglers benefit from improved water quality. Other recreational users whose use is curtailed due to weeds or unpleasant odors attributable to the nutrient loading benefit if nutrient loading is curtailed. People benefit who value fish habitat quality (even if they don't fish).
- *Qualitative Description of Benefits*—Greater recreational use occurs, and intrinsic benefits are higher.
- *Changes in Risks*—Health risks do not change. Risk of species decline falls.
- *Estimated Value*—Using Unit Day Values or results from previous non-market valuation studies, what range of change in user days is predicted for each recreational activity? What would be a conservative estimate of non-use benefits, e.g., the value of decreasing the risk of species decline? Such non-use benefits are described in chapter 4.

Summary of benefits, costs and risks, and their distribution:

- Which options yield the greatest benefit per expenditure?
- If the benefit estimates are highly uncertain, which options cost the least for comparable improvements in water quality?
- Do benefits exceed costs? Are benefits, costs, and risks to farmers such that they will most likely voluntarily adopt the measure(s)?

Summary of impacts on the four accounts:

- National Economic Development account with and without the project.
- Regional Economic Development account with and without the project.
- Environmental Quality account with and without the project.
- Other Social Effects account with and without the project.

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Chapter 4 Evaluation Techniques

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Chapter 4 Evaluation Techniques

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Chapter 4 Evaluation Techniques

612.0400 Introduction

The value of changes in water quality equals the sum of the associated changes in producer surplus and consumer surplus. Calculation of changes in producer surplus is based on changes in net income. Changes in consumer surplus usually are estimated with non-market valuation models.

612.0401 Changes in net income

Producer surplus changes are sometimes described as changes in net income. Producers may experience increased or decreased net income from changes in management practices that decrease nonpoint source pollution. Frequently, their net income decreases, the new management practice is more time-consuming, or some risk is associated with the change. Otherwise, one would expect the producers to have changed their management practices already. However, sometimes producers benefit from a change in management practices. For example, animal health benefits may decrease the producer's veterinary costs.

Analysis of net income with and without the change is necessary to learn the direct effects on net income of implementing source controls. Analysis of the direct effects on risk and management time may also indicate whether producers will want to adopt the change.

612.0402 Risk

Risks are perceived differently by affected individuals and are viewed as more or less acceptable based on parameters that are not always captured in risk analyses. As part of most risk analyses, possible outcomes from a course of action are inventoried. Values are assigned to each outcome, and the probability each outcome would occur is estimated. The product of each outcome's probability with its value is calculated. The sum of the products is an expected value of the course of action. Refer to chapter 3 and chapter 7 of the U.S. Army Corps of Engineers *Guidelines for Risk and Uncertainty Analysis in Water Resources Planning*, Volume I (Principles) and Volume II (Examples) for further details. The two volumes of this publication are available from the Natural Resources Conservation Service economists in the Northeastern States. The chapters cited describe how to implement the risk and uncertainty guidance in Principles and Guidelines, p. v, section 1.4.13 and in Supplement I to chapter 1.

Risk perceptions are influenced by more factors than the probability and severity of risk. Slovic, et al (1982) suggests the importance of other factors, especially whether the risk is voluntary or imposed, whether an outcome may be fatal, and the extent to which the risk is memorable, outside personal control, persistent over generations, and inequitably distributed. If any of these factors are present in the before or after scenarios, they will most likely influence the decision-maker's acceptance of or resistance to change.

612.0403 Methods to value non-market impacts

The change in consumer surplus resulting from a water quality improvement is determined from non-market valuation techniques (estimating values from environmental services). This handbook does not dictate a specific method to use when estimating non-market benefits. Examples of analyses are presented and can be modified to fit a particular situation.

Travel cost, Contingent Valuation, Unit Day Value, and other non-market valuation methods, such as hedonic pricing, may be appropriate to value non-market impacts. In the future, stated preference methods other than Contingent Valuation, such as the discrete choice experiments conducted for marketing research, may be applied more frequently to the valuation of non-market goods and services (see Adamowicz, Louviere and Williams 1994). The Travel Cost Method (TCM), Contingent Valuation Method (CVM), and Unit Day Values are described in section 2.8.2 of Principles and Guidelines. A more recent manual is provided by the Corps of Engineers (1986), National Economic Development Procedures Manual - Recreation. More recent developments have changed the field of non-market valuation extensively.

Several legal rulings pertain to the use of non-market valuation methods in the context of evaluating natural resource damages. Proposed guidelines are in Federal Register 15 CFR Chpt. IX (1/15/93), 15 CFR Part 990 (1/7/94), and 43 CFR Part 11 (5/4/94).

(a) Contingent valuation

The Contingent Valuation Method finds benefits by surveying people about how much they value a non-market good or environmental service in monetary terms. People are asked their willingness to pay for better environmental quality or the compensation they would require for a decline. The distribution of responses is then analyzed to determine an estimated value.

In various locations and contexts, monetary benefits of hunting, fishing, better water quality, pollution prevention and other non-market goods have been estimated from contingent valuation studies. Contingent valuation studies have also generated estimates for preventing pollutant damages. For a bibliography of contingent valuation studies, see Carson et al. (1993). Contingent valuation estimates of benefits and damages are expressed as dollar values as shown in example 4–1.

In example 4–1 the payment vehicle is pledges to a conservation fund. Under the proposed legal rules for the use of contingent valuation in natural resource damage assessments, one would not use a payment vehicle that had connotations of charity, 1) because some experts believe it is inappropriate to include money pledged for charitable motives in the value of environmental amenities, and 2) because the collection of a contribution is not viewed by respondents as certain to occur. The effects of payment vehicle were tested in the study of this example with an alternative county tax increase payment vehicle.

The ranges of value shown in the response task would bias responses to fall in the middle of the range of $1.00 to $39.00. To mitigate this problem, different versions of the questionnaire would need to be sent out with a variety of ranges shown in the contingent valuation questions. Alternatively, a questioning format other than the one shown in the example would be used to elicit payment amounts.

The proposed legal guidelines also steer researchers away from mail survey formats for contingent valuation studies. Telephone formats or combined mail and telephone formats are recommended instead of mail surveys, and in-person formats are preferred to either.

The Contingent Valuation Method may be capable of estimating non-use values, such as existence values. Observed/indirect methods, such as Travel Cost, are limited to a narrower range of applications than Contingent Valuation. In particular, the Travel Cost Method cannot be used to estimate non-use values.

Example 4–1 Using contingent valuation to value farmland protection

Dr. John C. Bergstrom, University of Georgia-Athens, directed a project to value protection of Greenville County, South Carolina, farmland (Bergstrom, Dillman, and Stoll 1985). A mail survey was sent to randomly selected Greenville County households in 1981 to 1982. The surveys elicited willingness to pay for protecting prime agricultural land. In one version of the survey instrument, respondents checked off the amounts they would be willing to contribute yearly to a conservation fund to protect all, 3/4, 1/2, and 1/4 of the prime farmland in Greenville County, e.g.:

Only 3/4 of the prime farmland in the county (54,000 acres) would be included in the protection program. Willingness to pay (yearly contribution to conservation fund)

Check or write in amount

___$1.00	___$9.00	___$17.00	___$25.00	___$33.00	
___$3.00	___$11.00	___$19.00	___$27.00	___$35.00	_____Other
___$5.00	___$13.00	___$21.00	___$29.00	___$37.00	(Write in amount)
___$7.00	___$15.00	___$23.00	___$31.00	___$39.00	

General questions about farmland activities and attitudes toward protection were elicited prior to the contingent valuation scenario. A page of information led up to the contingent valuation response task. Photographs of what the landscape looked like with and without protection were also included with the questionnaire.

The main concerns about using the Contingent Valuation Method may be subdivided into two general areas: first, whether people formulate values accurately in the context of a contingent valuation survey; and second, whether people truthfully reveal their value for a particular good or resource. Some researchers claim that if proper questionnaire construction and administration are practiced then these sources of error can be controlled (Mitchell and Carson 1989). Others prefer to use alternative valuation methods based on observable economic behavior, such as the Travel Cost Method (Hausman et al. 1992).

The Contingent Valuation Method is discussed in the Principles and Guidelines, section 2.8, appendix 2 to section VIII.

A satisfactory contingent valuation questionnaire generally takes more than a year to develop. The questionnaire is pretested extensively in focus groups and pilot studies. When responses are returned, they are coded and entered on computer (except in those cases where telephone interviewing is done in conjunction with data entry). Values are estimated from econometic models.

(b) Travel cost

The Travel Cost Method bases estimates of demand for a resource on information about the costs associated with visiting the resource. For example, the Travel Cost Method can be used to infer values for sport fishing, bird watching, or camping. The demand for these non-market goods is estimated based on observations about the number of people visiting the resource, the distance from which people travel to visit the resource, and other factors that may influence the demand curve, such as characteristics of the population and availability of substitute goods. These data generally are not readily available and must be collected from questionnaires, maps, and resource agencies. Example 4–2 shows travel cost data requirements for swimming in the Northeastern United States. An example of a travel cost model is in appendix G of the 3/86 US Army Corps of Engineers National Economic Development Procedures Manual - Recreation, IWR Report 86-R-4. An example of a study that explains and applies the Travel Cost Method to water quality valuation is given in a publication by Bockstael, McConnell, and Strand (1988).

Principles and Guidelines, part 2.8, appendix 1 of section VII, is about travel cost modeling.

(c) Unit Day Value

The Unit Day Value method estimates annual value of recreation use as the product of estimated average annual use and the value of a recreation day. This method takes values of recreation from tables in Principles and Guidelines section 2.8.3. The value for a day of recreation may be selected from a range provided by the tables; the selection is based on local prices for comparable recreation opportunities available through markets. Alternatively, a point system can be used to assign dollar values to a recreation day. The assignment of points is based on attributes of the recreation activity. The points are also given in Principles and Guidelines section 2.8.3 (table VIII-3-2).

Example 4–2 Travel cost data requirements for swimming in the Northeastern United States

As part of a larger 1989-1990 study of damages from acid rain in the Northeastern United States. A telephone screening survey asked respondents what water-related sports they had participated in during the preceding year (angling, boating, swimming). The survey also collected respondent socioeconomic data, such as age, education, race, and income. Analyses of non-responsive bias use such information.

A followup telephone survey about swimming included questions about the location of the site visited, the miles travelled by the respondent to visit the site and the time required to travel that far, whether transportation expenses were shared, reasons the respondent visited the site, amenities available at the site, ratings of water cleanliness at the site, scenery around the site, and trip expenses.

Example 4–3 illustrates a recreational benefit evaluation using the Unit Day Value method. This example shows the use of the Unit Day Value method to estimate recreation benefits from a water quality improvement. The analysis starts with identification of the impairment and discussion of linkages between practices and water quality impairment. Projected recreation with and without the project is compared, and a value estimated. This and remaining examples follow the worksheet format.

For more information, refer to Principles and Guidelines, appendix 3, section VIII, part 2.8. The Unit Day Value method is also described in appendix H of the U.S. Army Corps of Engineers National Economic Development Procedures Manual - Recreation (IWR Report 86-R-4).

Example 4–3 Unit Day Value method of estimating recreation benefits from a water quality improvement

Description of impairment	Sediment and phosphorous are entering Wildwood Lake, impairing boating, swimming, and fishing. Boating is especially impaired by sedimentation near docks, and by algae that catches in propellers. Swimming and fishing are affected by turbidity and algae growth. Historical data and baseline projections associate water quality impairments with reduced recreational use. The Wildwood Lake Association has been keeping attendance records since 1980 when conditions in the lake began to noticeably change. Recreation visits dropped from 70,000 to 65,000 per year. It is predicted that the value of cabins built on the north shore will decline if the lake continues to lose its appeal.
Cause and effect linkages	The interdisciplinary team determined that the sediment and phosphorous are the result of upstream cropland erosion. Phosphorous is transported to the lake via the sediment. Livestock operations also contribute to the phosphorous problem. In similar situations, septic systems around the lake could also be contributing nutrients to cause algae blooms.
Treatment measure(s)	The Association plans to dredge the lake areas with the greatest sedimentation. They assumed local sponsor leadership and have developed a plan to reduce future sediment loads.
Non-market benefits	Without the plan, recreation visitor days are predicted to decrease from the existing 65,000 to 40,000 in 25 years (a loss of 1,000 visitor-days each year). With the plan, the recreation visits are predicted to increase from 65,000 to 75,000 visitor-days over 5 years and to stay constant at 75,000 visitor-days thereafter. This 10,000 visitor-day increase is expected to result from improved water quality. Figure 4–1 shows the projected visits without and with the project. Value of a Visitor Day: Tables VIII-3-1 through VIII-3-3 in Principles and Guidelines are used to determine the Unit Day Value for a given project. The interdisciplinary team for Wildwood Lake determined that the current Unit Day Value is $6.10. With improved water quality as a result of the project, the Unit Day Value is expected to increase to $6.30 within the first year and remain constant thereafter.

Example 4–3 Unit Day Value method of estimating recreation benefits from a water quality improvement—continued

The benefits for recreation would be calculated as follows:

Value of future recreation without project

A decrease of 25,000 (65,000 – 40,000) visitor days over 25 years would average 1,000 days per year x 179.0653 (the present value of a decreasing annuity, 25 years, 8% interest) x $ 6.10 per day x .09368 (the 25 year amortization rate at 8%) = $102,326 average annual value. Adding the value of the 40,000 recreation day base, 40,000 x $6.10 = $244,000. The total future without project average annual value would be $102,326 + 244,000 = $346,326.

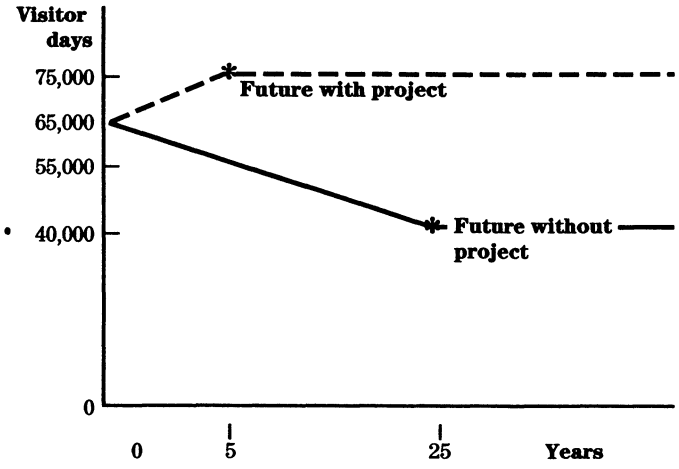
Value of future recreation with project

An increase of 10,000 (75,000 – 65,000) visitor days over a 5-year period would average 2,000 days per year x 11.36514 (the PV of an increasing annuity, 5 years, 8% interest) x $6.30 per day x .09368 (the amortization for 25 years at 8%) = $ 13,515 average annual value. Add the value of the 65,000 recreation day base = 65,000 x $6.30 = $409,500. The total with project average annual value would be $409,500 + $13,515 = $423,015.

Summary of benefits

Recreation values with and without the project are compared. The total average annual recreation benefits would be $423,015 – $346,326 = $76,689. The costs of the dredging and sediment control measures would be subtracted from the National Economic Development account. The monetary value of the annual recreation benefits are added to the National Economic Development account. The environmental effects, measured in physical terms, are shown in the Environmental Quality account.

Figure 4–1 Projected visits



(d) Hedonic pricing

Hedonic pricing is a method for calculating the demand for environmental services or some other non-marketed characteristic based on observed purchases of a marketed good. Price differentials in the marketed good are linked to differences in levels of environmental service and in levels of other characteristics. Like travel cost analysis, hedonic pricing is classified as an observed/indirect method for finding the value of an environmental service. The two most common applications of hedonic pricing use differentials in property values and in wages to infer demand for non-marketed characteristics.

Property values often already reflect many water quality values. Changes in property values can be an acceptable method for estimating the values of onsite and offsite water quality improvements. A qualified appraiser estimates property values with and without the project.

If property value appraisals are used, one must ensure that all the physical changes expected to occur with and without the project must be accurately described to the appraiser. Follow the procedures for establishing real estate values described in the draft of the Economics Handbook chapter, Land Easements and Right-of-Way. Maintenance of property values is described in Principles and Guidelines section 2.3.3(g).

Example 4–4 uses the change in property values method to estimate aesthetic damages to a lake from nutrients delivered by crop erosion. The Unit Day Value (UDV) method was used to evaluate the same water quality project in example 4–3. The impairment identification and cause-effect relationships are the same as before.

Hedonic pricing reflects benefits of improved recreation and aesthetics to private property owners. If recreation benefit estimates are available from an alternate method (Travel Cost, Contingent Valuation or Unit Day Value), adding the values together results in some benefits being counted twice. For example, the value in example 4–4 of $44,415 cannot be added to the UDV estimated recreation benefit of $76,689 determined in example 4–3. The value to the property owners for their lake recreation activities would be double-counted. The recreation benefits estimated to be attributable to property owners need to be subtracted from the sum to avoid double-counting.

In the rare event that benefits estimates are available both from a hedonic pricing study and from an alternate method, the economist would add the two estimates, but subtract recreation benefits accruing to property owners from the total. The corrected sum is reported in the NED account.

(e) Transferability from other studies

Often a previous valuation study will have been done for a similar resource problem. University professors, the EPA, professional journals, such as the Journal of Environmental Economics and Management, and State fish and game or environmental protection agencies are helpful for locating prior valuation studies. See also the Carson et al (1993) bibliography. If a previous valuation study has been done, its similarity and overall quality should be evaluated.

Differences between the resource(s) valued in the study or studies and the resource of interest should be identified. Dollar values should be normalized to constant dollars for a base year. Other factors that need to be examined would be differences in tourism rates, area population, and changes in the site itself from the previous time of study. If the site being evaluated was not previously studied, then differences between it and the site of the previous study should be carefully documented.

Example 4–4 The property value hedonic pricing method for estimating the benefits of water quality improvements

Quantify non-market benefits

Real estate agents and county appraisal records were used to determine that lakeside property values were 10 percent higher than these in surrounding areas under existing conditions. There were 27 homes located on the northern shore of the lake. The current average value of these homes is $50,000. The value of similar houses on a lake with deteriorated quality was estimated to be 10 percent lower (or $45,000). Wildwood lake would deteriorate to such conditions in 25 years.

The future without project average annual property values would be: $50,000 present value minus the $45,000 value at year 25 = $5,000 over 25 years, or an average of $200 decline per year x 179.06530 (the PV of a decreasing annuity, 25 years, 8% interest) x .09368 (the amortization rate for 25 years, 8% interest) equals $3,355 average annual value per house. Adding this to the $45,000 without project value of the home at year 25 yields $48,355. Multiplying this $48,355 by the 27 houses yields the average annual value of the lake property, $1,305,585.

The future with project average annual property values would be:

$50,000 x 27, or $1,350,000 average annual value

Summarize net benefits

The average annual project benefits for maintaining property values would be:

$1,350,000–$1,305,585 = $44,415

The average annual benefits of $44,415 would be reported in the National Economic Development account.

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

Part 612 Water Quality
National Resource Economics Handbook

Chapter 5 Benefit Categories

(200-vi, NREH, December 1995)

Chapter 5 Benefit Categories

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Chapter 5 Benefit Categories

612.0500 Introduction

Changes in water quality may impact producer costs and benefits in agriculture, industry, and commercial fishing. For example, an improved quality water supply may result in enhanced livestock health and production. Water quality improvements can save costs for maintaining navigation and for municipal and community water provision. Consumer surplus changes stem from recreational uses, human health impacts, fish and wildlife habitat changes (that consumers value), aesthetic values, existence values, and other non-market values.

612.0501 Water for agriculture

Agricultural water quality benefits are measured by net income effects.

(a) Domestic animal water use

Poor water quality can cause productivity and efficiency problems for domestic animals, such as reduced milk production, decreased fertility, weight loss, and increased mortality. Measurable economic effects include associated changes in veterinary bills, decreased marketable products, foregone use of by-products, or increased replacement costs.

Poor water quality can also shorten the useful life of equipment, such as pumps and other metal parts regularly exposed to water. For example, grit and suspended solids damage pump impellers. Improved water quality benefits for equipment generally consist of cost savings for operations, maintenance, and replacement.

Example 5–1 illustrates water quality benefits for a beef cattle operation.

Example 5–1 Water quality benefits for a beef cattle operation

In this example poor water quality impairs the water's usefulness for consumption by livestock. The proposed project would influence both quantity and quality of water.

Description of impairment Livestock producers in the Matzoth area face poor water quality due to high salt content in the soils. Matzoth is predominantly a cow-calf ranching area. Small ponds and dugouts hold rainwater. In low rainfall months, water levels drop and the water becomes very salty.

Treatment Without the project, the current water supply system includes the normal water supply plus an emergency water supply in drought years. The project would add a pipeline system. The proposed pipeline would bring higher quality water to the area.

Impacts The benefits of the project as a result of better water quality would be increased calf weaning weights and increased forage consumption because of more accessible and higher quality water. The producers currently wean calves at 500 pounds and they wish to increase weaning weights to 550 pounds. Local university research shows poor water quality causes stress on animals. Reducing this stress would increase weaning weights by 30 pounds per calf. An additional weight gain of 20 pounds would result from higher water consumption and improved grazing systems implemented with a new and better quality water supply.

The project would also change the costs of the overall water system. The cost of a pipeline water supply (including production input costs), and the cost of the current system of wells, dugouts, and reservoirs, including the cost of the emergency water supply (reduced variable production costs), would need to be determined and compared for a complete analysis. The difference in the cost with and without the pipeline system would be a benefit of the pipeline project.

Focusing on the increased calf weaning weights, the onsite market impacts for the producer would be an increase in over-all weights, and an increase in sale price per pound. Sales data for the last 5 years indicate an inverse relationship between weight and price per pound of feeder calves. A 500-pound calf sells for 99 cents per pound, and a 550-pound calf sells for 95 cents per pound.

The increased value per calf would be:

$$(550 \times .95)–(500 \times .99) = \$27.50 \text{ per calf}$$

The average annual benefit per calf for the new pipeline, including changes in the grazing systems and in water consumption, would be $27.50. These are National Economic Development benefits according to section 2.3.3(e) of Principles and Guidelines.

(b) Crop production

Water quality affects the quantity and quality of crop production. At some levels, nutrients in water may actually increase the production of some crops. High levels of pollutants, such as other chemicals or minerals (salt, iron) reduce yields. Refer to the Conservation Practice Physical Effects in the Field Office Technical Guide to determine the water quality effects of individual conservation practices. Physical and biological scientists need to be consulted to provide site specific information on the effects of practices for irrigation, drainage, animal waste management and land treatment practices.

Yield responses are estimated from case studies, when possible. The monetary effects of these changes can be measured using crop budgets which are available from USDA Extension Service. Natural Resources Conservation Service analysts often use the Cost and Return Estimator program (CARE) for crop budgeting. Project area farmers can verify crop budgets for appropriateness and accuracy. The Conservation Options Procedure (COP) described in the draft of part 622 of the forthcoming Economics Handbook provides a framework for evaluating crop production changes.

Example 5–2 is for potato crop production benefits from improved water quality.

Example 5–2 Crop production benefits from improved water quality

In this example, runoff from flood-irrigated potato fields increases dredging costs from offsite sediment impacts. In addition, erosion attributable to the irrigation system is causing long-term productivity losses. The proposed treatment, a change to sprinkler irrigation, will permit land that was formerly in ditches to be planted in crops, reduce weed control costs, reduce nitrogen use, reduce sediment damage to growing crops, change capital and operating costs, and reduce offsite impacts.

Impacts on water quality from present flood irrigation system	Often, adequately flood irrigating the lower end of a field can cause deep percolation in the upper end. This is caused by the long set (detention) times necessary to spread water over the entire field. Sediment from flood irrigation that runs off the land into nearby water can degrade surface water. Excessive leaching of nitrogen from the over-application of nitrogen and irrigation water can degrade ground water.
Treatment	Conversion from flood irrigation to sprinkler systems is proposed. Sprinkler systems have higher installation and energy costs and are more labor intensive. However, they use less water and use it more efficiently (less evapotranspiration).

Example 5–2 Crop production benefits from improved water quality—Continued

Onsite benefits of project Crop budgets were used to measure the difference in net returns per acre for changing from surface to sprinkler irrigation.

	Annual changes
Increased revenues per acre	$ 205
(includes revenue from cropland that was formerly in ditches, 1 acre per 40 acres @ $200 per acre = $5)	
Reduced water purchase (1 acre foot per acre @ $5)	5
Reduced OM&R on concrete ditch	66
Siphon tubes no longer needed $ .90 per tube & 12 tubes per acres x .093683[1/]	1
Reduction in irrigation labor (1 hour per acre)	8
Long term productivity loss from irrigation erosion	2
Reduced weed control costs @ $4 per acre	4
Reduced nitrogen use 75 lb @ $ .20 per lb	15
Reduced sediment damage to growing crops	3
Total onsite market benefits per acre	**$309**

[1/]Amortized at 8 percent for 25 years

Offsite market benefits of project

Item		Without conversion	With conversion	Change
		(Data provided by physical scientists)		
Nitrate leaching	(pounds)	225.0	150.0	75.0
Erosion	(tons)	46.0	2.0	44.0
Sediment yield	(tons)	4.0	0.1	3.9

Reduced dredging cost @ $4.87 per ton x 3.9 tons = $ 19

Offsite non-market benefits Converting flood irrigation to sprinkler systems could reduce adverse effects on surface and ground water.

Summary of costs and benefits Total benefits are valued at $309 per acre per year plus $19. These values are reported in the National Economic Development account. The new sprinkler system costs are subtracted from the National Economic Development account. The physical and environmental effects are reported in the Environmental Quality account.

(c) Agriculture waste management systems

Onsite benefits from improved agricultural waste management systems can include decreased disease-carrying pests (flies and rodents), improved animal health, changes in animal productivity, reduced onsite use of nutrients for crop production, and reduced labor requirements. If the nutrients are used, the farmer often avoids having to install alternative costly waste management systems. Offsite benefits may accrue to any of the benefit categories discussed in this guide if water quality is improved. The Conservation Options Procedure (COP) described in the draft of part 622 of the forthcoming Economics Handbook also provides a framework for evaluating animal waste management systems.

612.0502 Industrial water

Industrial water quality benefits are measured by net income effects. Industrial water uses are usually classified as boiler feed, cooling water, and process water.

Boiler feed is water that is boiled in thermal electric plants to make steam for space heating and use in industrial processes. Good water quality is important for boiler feed, consequently most boiler feed sources are treated before use.

Cooling water cools heated surfaces, primarily in producing electricity. Quality requirements for cooling water are not nearly as stringent as those for boiler feed; however, cooling water is sometimes treated to prevent scale and slime formations. Such formations require "blowdown" maintenance to remove them.

Process water removes or transports wastes, for example for vegetable rinsing and washing operations. Estimating a firm's producer surplus usually consists of estimating the improved water quality benefits from reduced water treatment costs.

Example 5–3 shows the industrial benefits from improved water quality. In this example, a utility uses water for cooling purposes. Water quality improvements reduce the frequency with which some filter screens need to be cleared. The utility saves money as a result. In the example, the water quality improvements come from better animal waste and cropland resource management systems.

Example 5–3 Industrial water benefits

This example shows industrial water benefits from a watershed project (Lake Konawa). Industry uses water to cool a natural gas electric generating facility.

Impairment

Significant amounts of nutrients enter the lake from cropland fields and concentrated livestock feeding operations. These pollutants produce large amounts of algae masses which clog filter screens and require back flushing of the screens. The backflushing must be done twice a day, which cost the utility company $500 per day in additional labor and added maintenance costs.

Treatment

The Konawa Watershed Plan consists of animal waste management systems and cropland resource management systems.

Impacts

If the Konawa Watershed Plan measures were installed, nutrients would be reduced by 50 percent and backflushing and additional maintenance by 60 percent.

Offsite market benefits

Present and future without plan treatment expenses were estimated to be:

$500 per day x 365 days per year = $182,500 average annual costs

Future treatment expenses with the Konawa Watershed Plan were estimated to be:

40% x $500 remaining labor and maintenance costs for backflushing x 365 days per year = $73,000 annual costs

The average annual cost savings in the treatment of industrial water were estimated to be:

$182,500–$73,000 = $109,500.

These cost savings are added to other plan benefits (onsite benefits of animal waste management systems, offsite non-market benefits from decreased nutrient loadings) in the National Economic Development account.

612.0503 Commercial fishing

Commercial fishery benefits are any net change in consumer and producer surplus because of an increase in catch per unit of effort. Changes in water quality can significantly influence commercial fish stocks and thus affect the fishing industry. Adverse impacts on commercial fisheries from poor water quality include:

- development of tumors or other growths or defects on fish,
- increased mortality rates caused by pollutant stress which leads to insufficient spawners,
- decreased body weight with lower sale price of fish,
- incorporation of toxics into tissues,
- pollutant stress that kills off macrophytes,
- sedimentation that leads to the destruction of the spawning habitat,
- disruption of spawning behavior or avoidance of the spawning habitat,
- pollution directly and indirectly disrupting the various trophic levels so that sufficient forage for commercial fish is no longer available, resulting in a reduction of adult spawning, and
- other impacts.

612.0504 Municipal and community water

Poor water quality often results in additional treatment costs for municipal water supply from costs of chemicals, more treatment processes, and additional energy needs, resulting in net income effects. Additional treatment costs are also incurred as the frequency of filter or screen flushing increases to clear accumulated suspended solids. Frequent flushing reduces the amount of processed water available, increases labor requirements and chemical use, and reduces equipment life.

Land use or crop rotation changes can effectively reduce the contaminants affecting domestic water supplies. An example of improved agricultural management resulting in cost savings for community and municipal water treatment is shown in example 5–4. An analysis of the changes using crop budgets could provide estimates of the costs of reducing contaminants.

Poor water quality could also impair the potability of water supplies (safety, taste, and odor). If this were the case, additional benefits would result from water quality improvements. Such improvements reduce or eliminate treatment costs, such as aeration systems, reverse osmosis, chemical additives, and granulated activated carbon filters. If water supply quality is extremely poor, alternative supply sources may be used for drinking water. In this case, benefit estimates would be based on the least costly replacement, such as a new rural water supply, bottled water imports, or other means of supplying potable water.

Example 5–5 illustrates how non-market benefits and municipal and industrial water treatment cost savings may both occur when better resource management systems result in improved water quality. In this example, acid run-off from an abandoned coal mine causes high treatment costs for reducing acidity of municipal water, and the acid water impairs fisheries. There are also differences with and without the project for hazardous substance disposal.

Example 5–4 Community water supply benefits from reduced cropland erosion and contaminant loading

This example shows the cost savings for treating the water for Hooper community when erosion management systems are installed.

Impairment

The agribusiness community of Hooper receives its water supply from nearby Lake Bed. Lake Bed has recently been subject to increased turbidity and phosphorus loadings from cropland sediment. The poorer water quality has resulted in increased water treatment costs. The community uses 170,000 gallons per day. The treatment cost is $0.0005 per gallon.

Treatment

Installation of the appropriate resource management system will decrease gross erosion by 30 percent.

Impacts

Published data indicate a 10 percent reduction in annual gross soil erosion will reduce the cost of treatment by 4 percent. A linear relationship is assumed, such that a 30 percent reduction in annual gross soil erosion would reduce the cost of treatment by 12 percent. The effect of the resource management system on the turbidity and phosphorous loadings is expected to be immediate. However, the time lag before there will be less phosphorus in the water supply is significant. For purposes of this example, suppose the benefits start to accrue in year four and the analysis is based on a 20-year project life of the resource management system.

Caution: A time lag of 4 years is unrealistically low. Sediment already in lakes is re-suspended during spring and fall turnover, re-entraining turbidity and phosphorus. Reducing erosion by 30 percent slows the eutrophication process, but a lake management plan is required for treating the water body.

Offsite Market Benefits (cost-savings)

Reduced treatment cost = 170,000 gal per day x $.0005 per gal. x .12 (the cost reduction) x 365 days = $3,723.00 per year beginning in year 4. At 5% interest, the present value of a 16 year stream of annual payments of $3,723 is $40,350 (using a factor of 10.838, the present value of an annuity of $1 per year for 16 years). Discounting back to year one from year four yields a present value of $33,208 (using a discount factor of .823). The average annual cost savings are reported as benefits in the National Economic Development account.

Example 5–5 Municipal and industrial water quality benefits

Impairments

A tributary flows through an abandoned coal mine and enters a stream 2,000 feet above the intake for the local water supply. The stream carries excess amounts of alkaline substances, sulfate, iron, magnesium, and aluminum from the coal mine. Water treatment procedures are required to remove these by-products, which are classified as hazardous waste materials. The acid mine drainage and sediment from the coal mine negatively impact the potential for sport fishing in the stream.

Treatment

The most cost effective solutions were to install anoxic limestone drains, construct wetlands for the mine discharge, and use traditional land treatment methods for eroding areas. The cost for installing the project treatment is:

	Item cost	Annuity*		Annual cost
Anoxic drain + wetland	$1,200,000	@ .09569	=	$114,828
Land rights	30,000	@ .09569	=	2,871
Sediment treatment cost	20,000	@ .09569	=	1,914
O&M cost	4,000		=	4,000
Total annual cost				**$123,613**

* Amount of annuity for a present value of 1 at an 8.25% discount rate for 25 years.

Impacts

As a result of the project, water treatment costs are reduced, and hazardous substance disposal costs are eliminated. In addition, water quality is improved sufficiently to support sport fish in the stream system.

Offsite market benefits

The project results in cost-savings in water treatment and in substance disposal. Physical scientists and city officials provided the following information:

	Without project costs	With project costs	Avoided costs
Water treatment cost	$20,000	$ 1,000	$ 19,000
Disposal of substance	8,000	0	8,000
Estimated offsite market benefits			**$27,000**

Example 5–5 Municipal and industrial water quality benefits—continued

Offsite non-market benefits

The project reduces sediment damages to stream habitat and opens new areas to recreational fishing. City officials describe the offsite damages caused by sediment. From a contingent valuation study habitat damages are estimated at $10,000 annually without the project, and they would be reduced to about $500 annually with the project. The recreation benefits of the project are estimated at $150,000. (The value of the new recreational fishing opportunities could have come from a contingent valuation study or from a travel cost study.) The estimated non-market offsite benefits are $159,500.

Summary

The offsite benefits total $186,500. They are reported as National Economic Development account benefits. The project costs of $123,613 are reported as National Economic Development account costs.

612.0505 Navigation

Sediment and corrosive substances in water can increase maintenance and shorten the lives of and otherwise damage vessels and associated navigation structures, such as locks, wharves, and pilings. Dredging is sometimes required. Reducing these maintenance costs produces benefits to navigation. Example 5–6 illustrates reduced dredging costs to maintain a channel for barge traffic when water quality is improved.

Example 5–6 Navigation benefits

After the completion of Oregon's Lower Granite Dam on the Snake River in 1975, slackwater river barge navigation was extended to the Lewiston-Clarkston area. The Army Corps of Engineers was responsible for maintaining a 15-foot navigation channel to the area. The Corps had estimated sediment deposition at the rate of 2,000,000 cubic yards of sediment per year.

Impairment

To maintain the barge channel, the Corps dredged 800,000 cubic yards annually from the critical area around the Port of Clarkston. State and local fishery agencies set a work window (between December 15 and February 15) during which the Corps was permitted to perform the dredging with the least effect on fish migrations.

Treatment

The watershed contributed 26,000 cubic yards of sediment to the area being dredged annually. With the project, the watershed would contribute only 6,000 cubic yards annually.

Impacts

The following costs and benefits were associated with sediment removal. Geologists and Corps' engineers provided the information. The baseline rate of sediment removal was 800,000 cubic yards per year. Without the project, the barge traffic would have had to be shut down at a cost of $120,000 or $ .15 per cubic yard ($120,000/800,000 yd^3). With the project, barge traffic would be shut down for a shorter time. Assuming a constant removal rate, benefits to the project would be:

Future without project	=	26,000	x	$.15	=	$3,900
Future with project	=	6,000	x	$.15	=	$900
Reduced cost of shut down	=	$3,900	–	$900	=	$3,000

Each ton of sediment prevented from entering the stream system reduces dredging costs. Present dredging cost are $4.50 per ton. Assume there are 0.8 cubic yard of sediment per ton ,then present dredging costs are estimated as $5.625 per cubic yard.

Navigation benefits

Future without project	=	800,000	x	$5.625	=	$4,500,000
Future with project	=	780,000	x	$5.625	=	$4,387,500
Benefits for reduced dredging costs	=	$4,500,000	–	$4,387,500	=	$112,500
Total benefits	**=**	**$112,500**	**+**	**$3,000**	**=**	**$115,500**

Summary

The annual cost savings from reduced dredging would be offsite benefits from the sediment control project. Thus, $115,500 is entered as a benefit in the National Economic Development account. The costs of the watershed plan and its other benefits were not calculated for this example. They would also show in the National Economic Development account.

612.0506 Human health

Health benefits are the reduction of exposure to carcinogens and toxins by way of ingestion, inhalation, or dermal contact. Health benefits may be associated with drinking water and with other beneficial uses of water, particularly water-based recreation and the consumption of uncontaminated fin and shell fish. Qualitative health effects that also occur should be shown in the Other Social Effects account.

Total benefits to human health are extremely difficult to quantify monetarily. Lost wages and productivity costs can be measured, but they only represent part of the costs to human health. Theoretically, the economic value of health benefits that might result from water quality improvements (the consumer surplus) would equal the sum of the affected individuals' willingness to pay for the reduction in the risk of contracting an illness. These illnesses might include infectious hepatitis, diarrhea, fever, and gastroenteritis.

Contingent valuation and hedonic pricing both apply to the problem of valuing risks to health and life. The framing of contingent valuation questions is particularly challenging in this context. When evaluating existing studies, one must assess whether the questions were framed in a way that allowed subjects to understand the risk levels posed. Example 5–7 shows the results from one contigent valuation study. Hedonic pricing in the context of valuing health risks usually takes the form of wage differential studies, where higher-risk occupations typically command higher wages for otherwise similar categories of work. The riskier occupations must generally add a risk premium to wages to attract workers. A review of literature about valuing risks to health and life is given by Viscusi (J. of Economic Literature, Dec. 1993).

An example where reduced health risks need to be counted in the estimated benefits from improved agricultural practices is where nitrates contaminate ground water. For example, Giraldez and Fox (1994) used the CREAMS model to predict reduction in nitrate leaching from changes in agricultural practices for the Southern Ontario village of Hensall. The reduced contamination of well water by nitrates was estimated. Annual benefits of improved ground water quality were found by combining the physical impact information with estimates found by other studies (i.e., contingent valuation studies) of damages from well water nitrate contamination.

Example 5–7 Value of health risks from a contingent valuation study

Viscusi, Magat, and Huber (1987) conducted a contingent valuation survey in which respondents were asked to value a reduction from 15 per 10,000 to zero of morbidity risks from insecticide exposure. The values were:

$1,504 for reduced risk of skin poisoning
$1,742 for reduced risk of inhalation
$3,489 for reduced risk of child poisoning

612.0507 Recreation

Water quality affects boating, swimming, sport fishing, waterfowl hunting, birdwatching, photographing wildlife, sailing, water skiing, and other forms of direct water contact and noncontact recreation. Recreation benefits are derived from increased user participation and satisfaction resulting from the water quality improvements. A shift to the right of the demand curve for recreation indicates increased benefits (figure 2–1, chapter 2, curve D'D'). The benefits are measured by the change in consumer surplus.

Value ranges for recreational activities from past nonmarket valuation studies are summarized in Walsh, Johnson, and McKean (1988). For example, they show values for various hunting activities and for cold water and warm water fishing. These value estimates are not directly transferable to new situations.

Most states have comprehensive outdoor recreation plans that are helpful in determining the supply and demand for various recreational activities. Information from the plans can be used with the Travel Cost and Unit Day Value methods. Example 4–3, chapter 4, illustrated the use of the Unit Day Value method to estimate recreation benefits.

For further information on the recreation evaluation process and the three primary evaluation methods: The Travel Cost Method (TCM), Contingent Valuation Method (CVM) and Unit Day Value (UDV) method, refer to part 612.0403 of this handbook.

612.0508 Aesthetic benefits

Aesthetic benefits come from qualitative appreciation of water quality by those who visit or live and work around it. Odor, unsightly shore deposits, accumulations of scum, foam, surface slicks, or other visible pollutants can adversely affect how individuals and society value property near the shoreline. Aesthetics effects include changes in the quality of recreational experiences. Because aesthetic effects often are not measurably associated with the direct use (the quantitative measure) of the water, they pose measurement and valuation difficulties.

Aesthetic benefits from water quality improvements can accrue to all water-based and water-enhanced recreational activities. The Travel Cost, Contingent Valuation, and hedonic pricing methods are useful for evaluating aesthetic benefits. The environmental quality criteria in Unit Day Value Guidelines for Assigning Points For General Recreation may also be used (table VIII-3-2 in Principles and Guidelines). Leisure research studies also sometimes estimate the value of improved aesthetics. Example 4–4 of chapter 4 uses the Hedonic Pricing method to estimate aesthetic benefits from a water quality improvement.

612.0509 Fish and wildlife habitat

Fish and wildlife habitat benefits result from the positive impact on the ecosystem of improved water quality. Fish and wildlife benefits are usually divided into two categories: consumptive recreation and nonconsumptive use. For example, an improvement in water quality could support an aquatic ecosystem by providing food, cover, and other needed elements for the survival and propagation of various species. This could lead to increased duck hunting (consumptive recreation) and increased habitat for an endangered species (nonconsumptive).

Consumptive recreational use benefits can be measured using the Travel Cost, Contingent Valuation, or Unit Day Value methods. Consumptive benefits may also be measured with market values depending on the specific species and existing markets. The effects on nonconsumptive uses would be described in the Environmental Quality and/or Other Social Effects accounts. If economic benefits from the nonconsumptive uses have been estimated from a contingent valuation study, these estimates might be reported in the National Economic Development account, depending upon study validity.

612.0510 Wetlands

Wetlands quantity and quality may be enhanced by project action. Contingent valuation studies can indicate how much the public is willing to pay to create wetlands, preserve wetlands, or improve wetlands quality in a region.

612.0511 Existence values

Existence values are those values that are not related to the current or expected future use of a resource. Existence benefits are derived from the knowledge that a resource (or some quality level of the resource) exists and will continue to exist. The value people hold for preserving endangered species, apart from any potential future commercial or hunting benefits they may derive, is an example of existence benefits.

Presently, only the Contingent Valuation Method is used to measure existence values. The Travel Cost Method does not assign benefits to existence values and will underestimate total value when existence values are present. However, the Contingent Valuation Method's use for estimating non-use values is controversial. If contingent valuation estimates are available for the total value of a water quality improvement, it may be helpful to comment on the extent to which non-use values are reflected in the contingent valuation estimates. Existence benefits should be described in the Environmental Quality account. Value estimates would be added to the National Economic Development account.

612.0512 Option values

Option values can be present if benefits of a project are uncertain or will occur in the future. In this case, the value of waiting before irreversible development takes place (the option value) may be undercounted by the Travel Cost Method. However, no empirical studies are available of the magnitude of this potential source of error.

612.0513 Other non-market items

Monetary values are difficult and sometimes impossible to place on some non-market goods, such as anxiety, distress, and other sentiments. These kinds of items can be discussed in the Other Social Effects or Environmental Quality accounts.

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Exhibits

Exhibit A—Policy Basis for NRCS Guide on Water Quality Economics

The USDA Water Quality Policy contains several provisions relating to economic assessment of water quality impacts. GM–401, Subpart B (DR 9500-7) states in part:

"The Department, in order to further promote the achievement of surface water and ground water quality goals, will...

(11) Continue to support and conduct research to identify cause-effect relationships between management practices and impacts on beneficial uses and to evaluate social costs and benefits associated with nonpoint control."

GM Part 401 Subpart A states in part:

"§401.2 Policy

To promote the improvement, protection, restoration, and maintenance of surface and ground water quality for beneficial uses, the Soil Conservation Service will...

(h) Support improved data gathering and research efforts to define and assess water quality and nonpoint source pollution areas, including economic offsite effects;

(i) Develop technical tools necessary to quantify the environmental and economic on- and offsite effects of soil and water conservation measures commensurate with their relative importance; ..."

Part 612, Water Quality, of the National Resource Economics Hnadbook is intended to disseminate information that can assist in implementing Natural Resources Conservation Service water quality activities.

Exhibit B—Least Cost Analysis

Background

The producer is growing corn and soybeans on 200 acres of Marshall, Monoa, and Ida soils. Soil loss from sheet and rill erosion is estimated to be 37 tons per acre per year. Ephemeral gully erosion directly affects 20 of the 200 acres.

Soil erosion depresses crop yields. Runoff enters Beaver Creek and is carried to a municipal water supply impoundment. Sediment associated with the runoff is reducing the storage capacity of the reservoir, and nutrients and other agriculture chemicals are suspected of affecting water quality in the reservoir.

The producer uses a moldboard plow. Fertilizer is applied in the fall to take advantage of price discounts and seasonal labor availability. A conservation planner has discussed three resource management systems (RMS) with the landowner to address the onsite and offsite effects of erosion.

RMS-1 Conservation tillage and conservation cropping sequence (no-till corn, chisel tilled soybeans), terraces, waterways, and contouring

RMS-2 Conservation tillage and conservation cropping sequence (no-till corn, chisel tilled soybeans), water and sediment control basins, waterways, and contouring

RMS-3 Conservation tillage and conservation cropping sequence (chisel tilled corn and soybeans), water and sediment control basins, waterways, and contouring

Each RMS treats sheet and rill erosion, ephemeral erosion, and reduces the amount of sediment and the associated agricultural chemicals entering Beaver Creek.

Strategy

The conservation planner assists the land user in evaluating the three proposed resource management systems.

Table A, developed with the land user, displays tradeoffs between the resource management systems. Cost information is shown along with each RMS's estimated effect on sediment, chemical, and nutrient runoff.

The land user would probably not adopt RMS-1 because no-till requires the use of additional chemicals to control weeds. Although the cost difference between RMS-2 and RMS-3 is small, RMS-3 uses mechanical weed control rather than chemical control, and therefore better addresses the local water quality concern about agricultural chemicals.

Based on the information in table A, the land user would probably select RMS-3.

Table A **Comparison of resource management systems**

Alternative	Sheet & rill erosion rate (t/a/y)	Sheet & rill erosion reduction (t/a/y)	Cost 1/ ($/ac)	Cost/ton 1/ ($/t)	Sediment 2/	Chemical	Nutrient
Current	37	0					
RMS-1	4	33	$18.97	$0.57	+	–	+
RMS-2	10	27	$10.03	$0.37	+	–	+
RMS-3	15	22	$ 7.30	$0.33	+	+	+

1/ Cost figures are expressed in average annual 1988 dollars. The interest rate is 9 percent.
2/ A "+" indicates a potential positive impact, and a "–" indicates a potential negative impact.