

**Preliminary Evaluation of  
Recreational Value Provided  
by Cherry Creek State Park**

*Prepared for:*

The City of Greenwood Village, Colorado

*Prepared by:*

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Cherry Creek State Park (hereafter CCSP), located in Englewood, Colorado, is an 880-acre state recreational park containing a large reservoir; it receives over 15% of the state park use in Colorado. Each year well over one million individuals visit the park for water-based activities such as fishing, boating, and water skiing; wetlands-based activities such as sightseeing and trail use; and other leisure opportunities such as a leash-free dog area and an area where model airplane aficionados go to fly their crafts. In an arid state such as Colorado, CCSP is a unique and valuable recreational resource, and the water quality of the reservoir is directly related to its value for recreational purposes. CCSP water quality issues related to phosphorus standards, and their potentially significant effects on recreation, have received heightened scrutiny recently in the local news media (Young, 2000; author unknown, 2000).

This report provides a cursory investigation into the likely order of magnitude of the total value of recreation at CCSP.<sup>1</sup> The findings reported here are based on a rapid review of available literature on CCSP, economic valuation literature on the quality of recreational resources, and user data. Our results demonstrate that the value of recreation at CCSP is sufficiently high to warrant careful consideration for any projects that would affect the water quality. The present value of all current and future recreational benefits that will be provided by CCSP under baseline (i.e., current) conditions may be over \$1 billion.

The services provided by CCSP are not limited to recreation. This resource also provides valuable services related to flood control, use as a potential drinking water source, and passive use values (i.e., values people hold because they know the resource is in good condition apart from any readily identifiable direct use). These other categories of services may also be affected by changes in water quality at CCSP, but they are not addressed here.

## **1. Estimation of Total Recreational Value**

The total value of recreation at CCSP has two components: what people actually do pay to visit the park and what they would be willing to pay over and above what they currently pay. The first component of value can be represented simply by the expenditures incurred. The second component deserves more explanation. Consumers purchase products in the marketplace because they are better off with the products than they were with the money needed to obtain the products (or whatever else they would have purchased with the money). If that were not true, goods and

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<sup>1</sup> Resumes of the principal investigators, William Breffle and Robert Raucher, are attached in the appendix.

services would not be exchanged through free will in the marketplace. Similarly, recreational site visits cost money, and recreationists would not undertake visits unless the visits yielded net benefits. Those net benefits are referred to by economists as “consumer surplus,” and are measured as willingness to pay (WTP).

Section 1 is divided into three subsections. In Section 1.1, an estimate of visitation expenditures is developed. Our figures account for park fees and other costs. In Section 1.2, preliminary estimates of consumer surplus are derived based on user data provided to us by CCSP and WTP “unit values” obtained from the literature. Finally, in Section 1.3 we combine expenditures and consumer surplus values to obtain estimates of total recreational value.

### 1.1 Recreational expenditures for visitation at CCSP

A lower bound estimate of annual recreational expenditures considers only park revenues. In 1999, park revenues were estimated to be \$1.04 million. This estimate of expenditures by recreationists is biased downward to a large degree because of the omission of other important cost categories. Total expenditures should include vehicle operating expenses (the cost of gasoline, oil, tires, and possibly depreciation and insurance, etc.) and the opportunity cost of time on site and in transit.

In an economic survey conducted in 1993 on CCSP, individual expenditures averaged approximately \$10 (Colorado State Parks, 1993), which is \$12 in 1999 dollars. Multiplying \$12 by the 1.4 million visitors in 1999 results in total recreational expenditures of \$16.8 million per year.

In the testimony of Dr. Robert Aukerman (1984) about his opinions on the value of recreation at CCSP, he stated that average trip expenditure per visitor per visit across all types of visitors and uses was approximately \$5. This figure was based on a primary on-site survey of recreationists in 1983 and would be roughly \$8 in 1999 dollars (Aukerman, 1984).<sup>2</sup>

An estimate per visit of around \$10 (the midpoint between \$8 and \$12) is reasonable when all relevant costs are considered. For example, we can assume the following:

- ▶ It costs \$0.325 per mile to operate a vehicle; this is the amount the federal government pays its employees for using their car for job-related activities (Internal Revenue Service, 2000).

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<sup>2</sup> Inflation multipliers in this report are obtained from the “Inflation Calculator,” located at <http://www.westegg.com/inflation>. The multipliers are based on the annual *Statistical Abstracts of the United States*.

- ▶ The value of time is considered only when in transit; there is no cost associated with on-site time.
- ▶ The typical person earns \$15/hour.
- ▶ A fraction of one-third is applied to the value of time, because it is not clear if the opportunity cost of time incurred for recreational purposes is really the full wage rate.
- ▶ Average travelling speed is 45 m.p.h.
- ▶ An average of \$5 of miscellaneous trip costs is incurred per person (e.g., fish lures or bait, suntan lotion, entry fee).

These reasonable assumptions would imply the average visitor lives approximately six miles away from the reservoir. In comparison, CCSP informs us 62% of the visitors come from within 10 miles of the park, and 81% come from within 20 miles. Therefore, per-person costs ranging from \$8 to \$12 are reasonable and conservative.

## 1.2 WTP-based estimates of value

The method of “benefits transfer” is a standard practice used by resource economists to obtain quick approximations of value when there is no opportunity to undertake primary research, such as administering a new survey or econometric model. Benefits transfer may be conducted simply by obtaining values per unit of use for similar types of activities from studies that have already been conducted in similar locations. Then those unit values are multiplied by the amount of use. A unit value typically might be the consumer surplus value for an activity such as a fishing day or a hiking trip.

Two different benefits transfer approaches are useful in determining aggregate annual consumer surplus for recreational trips to CCSP. In the Aukerman deposition, his survey results suggested that the average consumer surplus per user day ranged from \$3 to \$8 in 1983, or roughly \$5 to \$13 per day in 1999 dollars. These values were obtained using a contingent valuation survey. Applying this range to the 1.4 million 1999 visitors implies annual aggregate WTP for baseline levels of recreation at CCSP in the range of \$7.0 million to \$18.2 million.

We conducted a benefits transfer using a more comprehensive method and recent, peer-reviewed recreational valuation literature. We obtained unit values per day of use for each activity from a 1999 database compiled by John Loomis, a professor of economics at Colorado State University and expert in valuing environmental amenities. This database is a “meta-analysis,” which is an amalgamation of many individual studies to develop an estimate of central tendency. Meta-analysis is used to exploit and combine the strengths of multiple studies that use different

valuation methods, and to avoid being misled by a single potential outlier study. These values reflect the availability of substitutes.

Typically, two types of valuation methods are used in the literature and in the Loomis database: 1) revealed preference (RP) methods such as travel cost models, which use observed recreational behavior to infer values; and 2) stated preference (SP) methods such as contingent valuation, which ask people to state their values or their willingness to trade off different resource commodities. Carson et al. (1996) demonstrate that use values do not vary substantively whether RP or SP methods are used.

The Loomis database reports values for five regions of the United States. The values used in this report are taken from the values listed for the “Intermountain” region because they apply directly to Colorado. The recreation values summarized in the Loomis database are generally consistent with summary values obtained in other recreation meta-analyses, such as Boyle et al. (1999) and Walsh et al. (1990). For example, the Loomis value for fishing is \$32.45, which is similar to the value given in Walsh et al. (1990) of \$30.71 in 1999 dollars.

For each recreational activity offered at CCSP, Exhibit 1 lists the total number of user days in 1999 (as reported in the CCSP Park Manager’s Report),<sup>3</sup> the unit value per day, and the aggregate annual value computed as the product. The values are summed over all activities to yield a total recreational consumer surplus value of \$45.7 million. This is higher than the range of \$7.0 to \$18.2 million calculated using the Aukerman figures. Aukerman’s numbers indicate a generic value per recreational day of \$5 to \$13; a large body of literature on recreational values, including the studies used in the Loomis meta-analysis, indicates that a range of \$5 to \$13 per day is too low. The Loomis database reflects values from many credible studies, and we believe that the values listed are more appropriate to estimate consumer surplus at CCSP.

In addition to recreational opportunities, CCSP is a unique resource for the harvest of walleye eggs in Colorado (pers. comm., J. Woodling, Colorado Division of Wildlife, July 31, 2000). All walleye eggs for recreational fisheries are harvested from Cherry Creek and Pueblo Reservoirs. A total of 14 million walleye eggs are harvested from Cherry Creek reservoir per year at a value of \$0.05 per egg, totaling \$700,000. This annual value is added to total recreational consumer surplus, so the range becomes \$7.7 million to \$46.4 million per year.

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<sup>3</sup> The user days for each activity reported in the CCSP Park Manager’s Report are listed by the primary activity the visitor is engaging in, and therefore there is no double counting of user days in the data.

**Exhibit 1. Use and values for Cherry Creek State Park (1999 dollars)**

| <b>Activity</b>                   | <b>User days</b> | <b>Value per activity<br/>per day</b> | <b>Total activity value at<br/>CCSP</b> |
|-----------------------------------|------------------|---------------------------------------|---|
| Swimming                          | 123,687          | \$24.62                               | \$3,045,174                             |
| Fishing                           | 366,713          | \$32.45                               | \$11,899,837                            |
| Motor boating <sup>a</sup>        | 207,629          | \$50.48                               | \$10,481,112                            |
| Nonmotorized boating <sup>b</sup> | 23,266           | \$37.86                               | \$880,851                               |
| Sightseeing                       | 166,235          | \$24.60                               | \$4,089,381                             |
| Pedestrian use                    | 180,402          | \$24.60 <sup>c</sup>                  | \$4,437,889                             |
| Bicycling                         | 103,737          | \$58.89                               | \$6,109,072                             |
| Picnicking                        | 73,584           | \$22.95                               | \$1,688,753                             |
| Camping                           | 56,816           | \$25.06                               | \$1,423,809                             |
| Rifle range                       | 32,310           | \$24.60 <sup>d,e</sup>                | \$794,826                               |
| Interpretation                    | 24,719           | \$24.60 <sup>e</sup>                  | \$608,087                               |
| Model airplane                    | 7,599            | \$24.60 <sup>d,e</sup>                | \$186,935                               |
| Horseback riding                  | 6,293            | \$15.10 <sup>d</sup>                  | \$95,024                                |
| <b>Total</b>                      | <b>1,372,990</b> |                                       | <b>\$45,740,750</b>                     |

a. Motor boating is the sum of water skiing, personal watercraft (i.e., jet skis) use, and other motor boating activities.

b. Nonmotorized boating is the sum of windsurfing and other nonmotor boat activities.

c. National value given, because regional value was not available.

d. Value given is for sightseeing, because this particular use value was not available.

e. Value given (for sightseeing) will most likely underestimate the true value, because this activity is unique and site specific, with few substitutes available.

### 1.3 Combining the components of total recreational value

As described above, total recreational value is the sum of expenditures and consumer surplus. For expenditures, we use the estimate of \$16.8 million per year as our best estimate. Expenditures are added to the range of aggregate WTP (\$7.7 to \$46.4 million) to obtain a range for total annual recreational value of \$24.5 million to \$63.2 million (or \$43.8 million for water-based activity only).

The present value capitalized over the future can be computed using these annual values and a present value multiplier. This computation yields the total value of recreation at CCSP in perpetuity in today's dollars.<sup>4</sup> Values for future years are adjusted to reflect a real rate of discount; future benefits are not worth as much now as current benefits are worth now. For this computation, two real interest rates are used: a 3% discount rate is consistent with the average real three-month Treasury bill rates over the last 15 years (Bureau of Economic Analysis, 2000, Federal Reserve, 2000) and is consistent with U.S. Department of the Interior guidance (U.S. Department of the Interior, 1995) for natural resource damage assessments under 43 CFR § 11.84(e); a 7% discount rate may be more comparable to costs quoted by sewage plant dischargers (pers. comm., R. McGregor, Water & Waste Engineering, Inc., August 1, 2000).

CCSP data (as reported in the CCSP Park Manager's Reports) indicate that use has remained quite constant over the last 16 years. As such, our present value estimates of consumer surplus are based only on the most recent year for which data are available, 1999. A reasonable estimate of the aggregate present value over multiple years can be calculated by discounting or compounding the 1999 estimate over past or future years and summing. However, to the extent that use will increase in the future, basing future value on the current level of use will lead to an underestimate of future value.

Using a discount rate of 3%, the present value multiplier is 34.333, and the present value of current and future recreational benefits from CCSP ranges from \$841.2 million to \$2.2 billion (or \$1.5 billion for water-based activity only). Using a discount rate of 7%, the present value multiplier is 15.286, and the present value of current and future recreational benefits from CCSP ranges from \$374.5 million to \$966.1 million (or \$669.5 million for water-based activities only).

The main purpose of this effort is to obtain total value under baseline conditions, not to estimate the change in value due to some change in water quality, such as the infusion of additional phosphorus loadings. However, in Section 2 we discuss how current levels (and values) of

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<sup>4</sup> The present value multiplier consists of two parts:  $1 + 1/r$ . The first term accounts for the current (undiscounted) annual value; the second term converts annual future values into the present value of the perpetual stream of constant future values, where  $r$  represents the discount rate.

recreation might be altered by a reduction in environmental quality. Some literature is discussed to give the reader an idea of the potential magnitude of recreational losses that would occur because of decreases in water quality, and an illustrative scenario for possible effects at CCSP is developed.

## 2. Professional Opinion on the Possible Losses due to Decreased Water Quality

Primary research has shown that environmental degradation can affect recreation and cause recreational damages in two ways:

1.) *Fewer trips might be taken to the affected site.* Recreationists may substitute away from the affected sites to other sites that would be less preferred in the absence of injuries, because of distance or characteristics (Morey et al., 2000), or they may participate in recreation less or not at all. CCSP is currently being used to capacity during some periods, with long lines at the entrance on weekends. Changes in environmental quality might lead to reductions in usage.

2.) *Recreational trips to the affected site will be valued less.* Recreationists may continue to participate at the affected site, out of habit or because there are no good substitutes available. The more unique the site, the less likely it is that recreationists will be able substitute away; CCSP is somewhat unique regionally, although there are other proximate recreational sites, such as Aurora Reservoir. However, it is not to imply that damages will not occur if use does not decrease. In fact, unique sites are typically more highly valued (Breffle et al., 1999) and have low elasticities of demand (meaning that as price or quality changes, quantity demanded changes very little). The identical environmental insult, for example, would cause much greater damage at the Grand Canyon than at some unknown mesa in New Mexico, even if people would still visit the Grand Canyon en masse.

Some of the literature investigating the incremental impact of environmental changes is described below. These are illustrative to demonstrate that environmental degradation does affect people's behavior and values.

- ▶ A new study on Green Bay recreation found that fish consumption advisories (FCAs) cause a value reduction of \$9.75 per Green Bay fishing day, or about a 20% decline in overall value per day (Breffle et al., 1999).
- ▶ A study of Tennessee reservoirs found that removal of FCAs was valued by fishermen from \$1.56 to \$7.62 per trip to all reservoirs in 1999 dollars (Jakus et al., 1998).

- ▶ Needelman and Kealy (1995) found swimmers in New Hampshire's lakes value improvements in water quality. The per person per day WTP to eliminate eutrophication is \$1.53 in 1999 dollars, and to eliminate all pollution problems, WTP is \$4.70 in 1999 dollars.
- ▶ Annual values for a water quality change in the Monongahela River in Pennsylvania from fishable to swimmable range from \$18 to \$37 in 1999 dollars (Desvouges et al., 1987).

Information is currently unavailable to determine how much total recreational value would be affected at Cherry Creek State Park by reduced water quality, such as injury due to the addition of phosphorus loadings. To illustrate the potential losses, for strictly illustrative purposes, suppose that a decrease in water quality causes a decrease in use of 10%, so 10% of recreational value is lost. This change is consistent with the literature for significant environmental changes; see for example Breffle et al. (1999) and Shaw (1985). Further suppose that the value of recreational activity that continues to occur is reduced by 20%, causing a further decrease in recreational value of 18% (90% continued use multiplied by a 20% decrease in value). Combined, the effects would result in a 28% decrease in value, as reported in Exhibit 2. Annual recreational losses would range in the tens of millions, and the present value of future losses would range in the hundreds of millions.

**Exhibit 2. Potential losses in total recreational value at Cherry Creek State Park from decreases in water quality (millions of 1999 dollars)**

| Recreation activity                 | Baseline range of total recreational value | Loss from 10% reduction in use and 20% reduction in value of continued activity |
|-------------------------------------|--|---|
| All activities                      |  |   |
| annual                              | \$24.5 to \$63.2                           | \$6.9 to \$17.7   |
| present value (3%)                  | \$841.2 to \$2,169.8                       | \$235.5 to \$607.5  |
| present value (7%)                  | \$374.5 to \$966.1                         | \$104.9 to \$270.5  |
| Water-based activities <sup>a</sup> |  |   |
| annual                              | \$24.5 to \$43.8                           | \$6.9 to \$12.3   |
| present value (3%)                  | \$841.2 to \$1,503.8                       | \$235.5 to \$421.1  |
| present value (7%)                  | \$374.5 to \$669.5                         | \$104.9 to \$187.5  |

a. Where possible, only values for water-based activities are included. However, values from the Aukerman study and expenditure figures could not be broken down by type of activity.

### 3. Secondary Economic (Spillover) Effects and Regional Multipliers

Decreased water quality in CCSP may result in other economic losses outside of the park not related directly to the recreationists or the park. Aukerman pointed out in his deposition that recreational expenditures affect the regional economy indirectly through tax revenues, profits to recreation-related businesses such as boating goods stores and fishing equipment retailers, and concessionaire operations, to name a few (Aukerman, 1984). When expenditures on recreation change, it generates (or removes) a stimulus for the economy; the regional economy will be affected through a “multiplier.” The multiplier is a factor that when multiplied by expenditures (or reductions in expenditures) yields the benefits (or reductions in benefits) to the region. While we do not have precise estimates of the multiplier for CCSP, some related literature provides some guidance.

Cordell et al. (1990) estimated regional economic multipliers of 2.00 and 2.03 for the total economic effects of water-based recreation expenditures on local economies. Norton et al. (1981) estimated a range of multipliers from 2.03 to 2.88 in an analysis of the economic value of striped bass fishing. Exhibit 3 displays the complete regional economic value of recreation at CCSP when applying a range of economic multipliers from 2.00 to 2.88 to recreational expenditures. Expenditures plus secondary regional effects range from \$33.6 million (2.00 multiplied by \$16.8 million in expenditures) to \$48.4 million (2.88 multiplied by \$16.8 in expenditures).

Annual CCSP total recreational values including multiplier effects range from \$41.5 to \$94.8 million for all activities, and up to \$75.4 million for water-based activities. Using a discount rate of 7%, the present value of future use in perpetuity may range from \$634.3 million to \$1.4 billion for all activities, and up to \$1.2 billion for water-based activities. Under the injury scenario described in Section 2, the present value of losses range in the hundreds of millions.

**Exhibit 3. Potential total losses including recreational values and secondary regional effects from decreases in water quality at Cherry Creek State Park (millions of 1999 dollars)**

| Recreation activity                 | Baseline range of total recreational value | Loss from 10% reduction in use and 20% reduction in value of continued activity |
|-------------------------------------|--|---|
| All activities                      |  |   |
| annual                              | \$41.5 to \$94.8                           | \$11.6 to \$26.5  |
| present value (3%)                  | \$1,424.8 to \$3,254.8                     | \$398.9 to \$911.3  |
| present value (7%)                  | \$634.3 to \$1,449.1                       | \$177.6 to \$405.7  |
| Water-based activities <sup>a</sup> |  |   |
| annual                              | \$41.5 to \$75.4                           | \$11.6 to \$21.1  |
| present value (3%)                  | \$1,424.8 to \$2,588.7                     | \$398.9 to \$724.8  |
| present value (7%)                  | \$634.3 to \$1,152.6                       | \$177.6 to \$322.7  |

a. Where possible, only values for water-based activities are included. However, values from the Aukerman study and expenditure figures could not be broken down by type of activity.

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# **Appendix**

**WILLIAM S. BREFFLE****Areas of Qualification**

Environmental and natural resource economics, econometrics and statistics, microeconomic theory, survey design

**Employment History**

- ▶ Senior Associate, Stratus Consulting Inc., Boulder, CO, 1999-present
- ▶ Teaching Assistant, Department of Economics, University of Colorado, 1996-1999
- ▶ Advisor, Stratus Consulting Inc., Boulder, CO, 1998-1999
- ▶ Advisor, 1996-1997, Associate, 1995-1996, Hagler Bailly, Inc., Boulder, CO
- ▶ Associate, RCG/Hagler Bailly, Inc., Boulder, CO, 1992-1995
- ▶ Research Assistant, Center for Economic Analysis, Department of Economics, University of Colorado, 1991-1992
- ▶ Teaching Assistant, Department of Economics, University of Colorado, 1992

**Education**

- ▶ University of Colorado, PhD, Economics, 1999
- ▶ University of Colorado, MA, Economics, 1992
- ▶ University of Colorado, BA, Economics, 1990

**Professional Experience**

Dr. Breffle is an environmental economist with expertise and eight years of experience in recreation demand modeling, conjoint analysis using choice questions, the contingent valuation method, and natural resource damage assessment (NRDA). He has conducted primary economic research for projects involving metals, petroleum hydrocarbons, and organics contamination in many different states, and has supervised the collection, management, and analysis of revealed preference and stated preference data at the NRDA level of QA/QC. Dr. Breffle has also investigated the economic effects of climate change, the costs of compliance with drinking water regulations, and the economic benefits of water quality regulations.

**Green Bay NRDA Recreation Valuation and Resource Equivalency Studies**

1999-Ongoing

Client: U.S. Fish &amp; Wildlife Service

Dr. Breffle is a primary investigator on the economics portion of this NRDA. He conducted econometric analysis of stated-preference choice data and stated-preference and revealed-preference frequency data on recreational fishing. Models combining the two types of data and models with random parameters were designed and estimated by Dr. Breffle. Damage estimates from the presence of fish consumption advisories in Green Bay were reported. The report has been downloaded from the U.S. Fish & Wildlife web site over 26,000 times. Dr. Breffle is also designing models to estimate individual preferences and the willingness to trade off different site attributes using choice question data collected from the general public living near Green Bay to develop and evaluate restoration options.

**Natural Resource Damage Assessment in the Upper Clark Fork River Basin**

1992-1997

Trustee: State of Montana

The Clark Fork NRDA was conducted to measure recreational damages to anglers and other recreationists resulting from industrial injuries to the upper Clark Fork River Basin. This site is geographically the largest Superfund site in the United States. Dr. Breffle assisted in the development and estimation of a state-of-the-art multinomial nested logit recreation demand model of participation and site choice for anglers who fish in southwestern Montana. He managed data from many primary survey efforts involving several thousand recreationists throughout an entire fishing season and provided extensive econometric and other statistical analyses.

The damage assessment for the Clark Fork River Basin also included measurement of total direct and passive use values for injuries using the contingent valuation method. Dr. Breffle managed all data collected by a contingent valuation survey of over 1,000 Montana residents, and he performed statistical and econometric analyses. Dr. Breffle prepared results and coauthored reports on recreational damages and willingness to pay for cleanup of injured Clark Fork River sites for the State of Montana Natural Resource Damage Litigation Program.

**Preliminary Natural Resource Damage Assessments**

1994-Ongoing

Trustees: U.S. Department of the Interior: U.S. Fish &amp; Wildlife Service Bureau of Indian Affairs; multiple states; numerous Native American Tribes

Dr. Breffle conducted the preliminary evaluation of compensable damages and compensatory restoration costs for mining contamination in a mid-western mining belt for multiple state,

federal, and tribal trustees, including the U.S. Department of the Interior. NOAA's habitat equivalency analysis (HEA) method was applied. He also contributed to preliminary evaluations of damages from PCB and other organics contamination in Michigan and Wisconsin, and he investigated petroleum-related human use service flow injuries in central California.

### **Evaluation of Type A Natural Resource Damage Assessment Model for Oil Spills**

1996

Client: U.S. Department of the Interior, subcontracted through ASA, Inc.

Dr. Breffle conducted a review of the economic results from the Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME), which is a Type A model that relies on existing literature to estimate the economic damages resulting from oil spills. This review included a comparison of Type A damage predictions with damages estimated in trustee assessments, and with legal settlements. Differences between the Type A estimates, trustee estimates, and settlements are discussed within a framework of human use service flows.

### **Natural Resource Damages Caused by Oil Spills in British Columbia**

1995

Trustees: Environment Canada and the B.C. Ministry of the Environment

Dr. Breffle was involved with multiple ongoing projects that focused on the valuation of all service flow reductions caused by large oil spills in British Columbia waters. A primary objective was the development of a contingent valuation survey to value the impacts of multiple oil spill scenarios. Dr. Breffle estimated the benefits (damages avoided) of accelerating the replacement of single-hulled vessels with those having double hulls, and he also estimated the benefits of a program to establish a rescue/salvage tug to serve Canada's west coast.

### **Natural Resource Damage Assessment in the Coeur d'Alene River Basin**

1995

Trustees: Coeur d'Alene Tribe, U.S. DOI, U.S. Forest Service

Dr. Breffle investigated recreation demand modeling issues pertinent to this NRDA. Natural resource injuries include metals contamination at multiple sites. For this project, he designed and implemented detailed recreation surveys for Coeur d'Alene and the Pacific Northwest.

### **Regulatory Impact Analysis of the Great Lakes Water Quality Guidance**

1995

Client: U.S. Environmental Protection Agency

This project was conducted to estimate economic costs and benefits associated with water quality regulations in the Great Lakes Basin. Dr. Breffle conducted an investigation of contaminant

sources in the basin, and estimated recreational, commercial, and passive use benefits expected to result from the Guidance.

### **Climate Change and Human Health**

1994-1995

Client: University of Delaware

Dr. Breffle developed econometric models and other statistical analyses to identify socioeconomic and climatic factors influencing mortality caused by offensive summer weather masses. The study concluded that availability of air conditioning, standard of living, and housing quality may all be statistically related to excess heat-induced mortality. Dr. Breffle also assisted in the estimation of human-health damages associated with climate change. These values were based on willingness to pay to avoid increased risks of mortality.

### **Estimating the Cost of Compliance with Drinking Water Standards**

1993-1994

Client: American Water Works Association Research Foundation

Dr. Breffle contributed to a “user’s guide” to provide conceptual and empirical guidance for how to best estimate contaminant occurrence and the costs of compliance with federal drinking water standards. His area of focus on this project was water-system size and configuration to address the issues of the needed scale of treatment for water suppliers across different system size categories. The guide was published by AWWARF.

### **Valuing Undeveloped Urban Land in Colorado**

1992

Dr. Breffle conducted a contingent valuation study to estimate the value of preserving undeveloped urban land in Boulder, Colorado. The project included the design and implementation of a contingent valuation survey to estimate neighborhood willingness to pay for preservation, and the development of an ordered-probit econometric model. The results were used by the Boulder City Council for policy decisions regarding undeveloped land.

### **Selected Publications**

Breffle, W.S. and E.R. Morey. Investigating preference heterogeneity in a repeated discrete-choice recreation demand model of Atlantic salmon fishing. *Marine Resource Economics*. Forthcoming.

Breffle, W.S., E.R. Morey, and T.S. Lodder. 1998. Using contingent valuation to estimate a neighborhood's willingness to pay to preserve undeveloped urban land. *Urban Studies* 35(4):715-28.

Breffle, W.S., E.R. Morey, R.D. Rowe, and D.M. Waldman. Combining stated-choice questions with observed behavior to value NRDA compensable damages: A case study of recreational fishing in Green Bay and the Lower Fox River. In *The Handbook of Contingent Valuation*. D. Bjornstad, J. Kahn, and A. Alberini (eds.). Edward Elgar Publishing, Northampton, MA. Forthcoming.

Chestnut, L.G., W.S. Breffle, J.B. Smith, and L.S. Kalkstein. 1998. Analysis of differences in hot-weather-related mortality across 44 U.S. metropolitan areas. *Environmental Science and Policy* 1(1):59-70.

Raucher, R., J. Drago, E. Castillo, A. Dixon, W.S. Breffle, and D. Waldman. 1995. *Estimating the Cost of Compliance with Drinking Water Standards: A User's Guide*. American Water Works Association Research Foundation, Denver, CO.

Rowe, R.D., W.D. Schulze, and W.S. Breffle. 1996. A test for payment card biases. *Journal of Environmental Economics and Management* 31:178-185.

### **Under Review**

Breffle, W.S., E.R. Morey, and D.M. Waldman. Combining sources of data in the estimation of consumer preferences: Estimating damages to anglers from environmental injuries. Under review at *The Review of Economics and Statistics*.

Breffle, W.S., D.M. Waldman, and E.R. Morey. Gaussian quadrature versus simulation for the estimation of random parameters: Some evidence from stated preference recreational choice data. Under review at *Economics Letters*.

Morey, E.R., W.S. Breffle, and P.A. Greene. Two nested CES models of recreational participation and site choice: an 'alternatives' model and an 'expenditures' model. Revise and resubmit at *The American Journal of Agricultural Economics*.

Morey, E.R., W.S. Breffle, R.D. Rowe, and D.M. Waldman. Estimating the damages from injuries to trout in Montana's Clark Fork River. Under review at *Water Resources Research*.

### **Selected Working Papers**

Breffle, W.S. Recreation demand methodology and the estimation of nonresident values. Department of Economics discussion paper, University of Colorado at Boulder (1996).

Lazo, J.K., W.S. Breffle, and L.G. Chestnut. Households' willingness to pay for improved weather forecasts: a conditional probit analysis using stated choice data. Stratus Consulting discussion paper (2000).

### **Selected Presentations**

Breffle, W.S. and E.R. Morey. 1999. Investigating heterogeneity of preferences in a repeated logit recreation demand model using RP data. Presented at the W-133 Regional Research meetings, Tucson AZ, February 25.

Breffle, W.S., E.R. Morey, and D.M. Waldman. 2000. Combining sources of data in the estimation of consumer preferences: estimating damages to anglers from environmental injuries. Presented at the W-133 Regional Research meetings, Kauai HI, March 1.

Lazo, J.K., W.S. Breffle, and L.G. Chestnut. 2000. Households' willingness to pay for improved weather forecasts: a conditional probit analysis using stated choice data. Presented at the University of Colorado Environmental and Resource Economics Workshop, Boulder CO, July 17.

Morey, E.R., W.S. Breffle, and P.A. Greene. 1999. Two share models of recreational participation and site choice. Presented at the AERE sessions of the AEA meetings, New York City, January 3.

### **Selected Technical Reports**

#### **Natural Resource Damage Assessment**

Assessment of Damages to Anglers and Other Recreators from Injuries to the Upper Clark Fork River Basin. E.R. Morey, R.D. Rowe, W.S. Breffle, and W.D. Shaw. Prepared for the State of Montana Natural Resource Damage Litigation Program. 1995.

Compensable Natural Resource Damage Determination for the Upper Clark Fork River NPL Sites. R.D. Rowe, E.R. Morey, W.D. Schulze, and W.S. Breffle. Prepared for the State of Montana Natural Resource Damage Litigation Program. 1995.

Contingent Valuation of Natural Resource Damages due to Injuries to the Upper Clark Fork River Basin. R.D. Rowe, W.D. Schulze, W.S. Breffle, R. Boyce, and G. McClelland. Prepared for the State of Montana Natural Resource Damage Litigation Program. 1995.

Evaluation of Type A Oil Spill Model. W.S. Breffle, R.D. Rowe, and M.P. Welsh. Prepared for Applied Science Associates, Inc. 1996.

An Introduction to the Resources and Services Equivalency Approach and its Application to the Guadalupe NRDA. R.D. Rowe, R.S. Bishop, W.S. Breffle, and M.P. Welsh. *Confidential Draft Report*. Prepared for the California Department of Fish and Game. 1996.

Preliminary Evaluation of Damages: Lower Fox River and Green Bay NRDA. *Confidential Attorney/Trustee Work Product*. W.S. Breffle, R.D. Rowe, and M.P. Welsh. Draft Report prepared for the U.S. Fish and Wildlife Service, Green Bay, WI. 1995.

Preliminary Evaluation of Damages for the Kalamazoo River NRDA. *Confidential Attorney/Trustee Work Product*. W.S. Breffle, B. Hurd, and W.D. Shaw. Draft report prepared for the State of Michigan Department of Natural Resources and Attorney General's Office. 1994.

Preliminary Evaluation of Injuries and Damages for the Red River Basin NRDA. *Confidential Attorney/Trustee Work Product*. M. Barron, W.S. Breffle, J. Holmes, A. Maest, and A. Patterson. Prepared for the State of New Mexico Office of the Natural Resources Trustee. 1994.

Preliminary Evaluation of Potential Compensable Natural Resource Damage and Primary and Compensatory Restoration: Tristate Mining District. *Confidential Attorney/Trustee Work Product*. W.S. Breffle and D. Mills. Prepared for the States of Kansas, Missouri, and Oklahoma; the U.S. Fish & Wildlife Service; the U.S. Bureau of Indian Affairs; and the Quapaw Tribe. 1999.

Preliminary Evaluation of Public Use Injuries and Damages for the Guadalupe NRDA. *Confidential Attorney/Trustee Work Product*. W.S. Breffle, R.D. Rowe, and M.P. Welsh. Prepared for the California Department of Fish and Game. 1996.

Pretest Results of the 1992 Hazardous Waste Sites Contingent Valuation Method Pretest. *Confidential Attorney/Trustee Work Product*. W.S. Breffle, R.D. Rowe, and W.D. Schulze. 1993.

Recreational Fishing Damages from Fish Consumption Advisories in the Waters of Green Bay. W.S. Breffle, E.R. Morey, R.D. Rowe, D.M. Waldman, and S. Wytinck. Prepared for the U.S. Fish and Wildlife Service, the U.S. Department of Interior, and the U.S. Department of Justice. 1999.

Valuing Environmental Damages from Oil Spills on the Pacific Coast Phase 1A: Literature and Scenarios. W.S. Breffle and R.D. Rowe. Prepared for Environment Canada. 1995.

### **Benefit-Cost Analysis**

Benefit-Cost Analysis of Establishing a Dedicated Rescue/Salvage Tug to Serve Canada's Southern West Coast. E. Castillo, W.S. Breffle, L. Bird, R.D. Rowe, R. Allan, and D. Dickens. Prepared for the B.C. Ministry of the Environment. 1995.

Benefit-Cost Analysis of Expediting the Schedule for Double-Hulling Oil Tankers and Barges Operating in and near British Columbia Waters. E. Castillo, W.S. Breffle, L. Bird, R.D. Rowe, and D. Dickens. Prepared for the B.C. Ministry of the Environment. 1995.

Critique of the Canadian Coast Guard/CCME Benefit-Cost Analysis of Expediting the Schedule for Double Hulling in Canada. E. Castillo, W.S. Breffle, and R.S. Raucher. Prepared for the B.C. Ministry of the Environment. 1995.

Regulatory Impact Analysis of the Final Great Lakes Water Quality Guidance. E. Castillo, R.S. Raucher, M. Barron, W.S. Breffle, S. Keefe, and A. Patterson. Prepared for the U.S. Environmental Protection Agency, Contract #68-C4-0060, WA#04. 1995.

### **Climate Change and Human Health**

Differences in Summer Mortality Due to Climate in U.S. Cities. L. Chestnut, W.S. Breffle, E. Castillo, and J.B. Smith. Prepared for the Center for Climatic Research, Department of Geography, University of Delaware. 1995.

Estimates of Willingness to Pay for Potential Changes in Risks of Mortality Due to Climate Change. L. Chestnut, W.S. Breffle, and J.B. Smith. Prepared for the Center for Climatic Research, Department of Geography, University of Delaware. 1995.

Estimation of Human Health Monetary Damages as a Result of Increases in Temperature. J.B. Smith and W.S. Breffle. Draft report prepared for the Electric Power Research Institute. 1994.

The Impact of Climate Change on Thermoelectric Power Use in Egypt and Poland. J.B. Smith, F. Stern, C. Yermoli, and W.S. Breffle. Prepared for the International Institute for Applied Systems Analysis. 1994.

**Professional Affiliations and Honors**

- ▶ Graduate Student Research and Creative Work Award, nominee, 1999
- ▶ Reuben A. Zubrow Graduate Fellowship Award for the Teaching of Economics, 1998-1999
- ▶ Graduate School University Fellowship, 1996-1997
- ▶ University of Colorado Honor Graduate (equivalent to valedictorian), *summa cum laude*, School of Arts and Sciences, 1990
- ▶ University of Colorado Dean's Scholar, 1988-1990
- ▶ University of Colorado Regent Scholar, 1987-1988
- ▶ American Economics Association (AEA)
- ▶ Association of Environmental and Resource Economists (AERE)
- ▶ Phi Beta Kappa
- ▶ Omicron Delta Epsilon (National Economics Society)

**ROBERT SHAFER RAUCHER****Areas of Qualification**

Environmental economics and public health, including benefit-cost and regulatory analysis, for public water supply and natural resource issues, natural resource damage assessment, environmental risk management, and strategic planning

**Employment History**

- ▶ Executive Vice President, Stratus Consulting, Boulder, CO, 1998-present
- ▶ Director, Hagler Bailly, Boulder, CO, 1995-1998; Vice President, 1986-1995
- ▶ Chief, Water Economics Branch, Office of Policy Planning and Evaluation, U.S. Environmental Protection Agency, 1984-1986; Economist, Benefits Analysis Staff, 1980-1984
- ▶ Economic Consultant, Han River Basin Environmental Master Plan Project, Asian Development Bank and Ministry of Health, Republic of Korea, Seoul, 1983
- ▶ Economic Consultant, Energy and Environment Group, Temple, Barker and Sloane, Inc., Lexington, MA, 1979-1980
- ▶ Policy Analyst, Welfare Reform Commission Study Group, Division of Policy and Budget, Wisconsin Department of Health and Social Services, Madison, 1978-1979
- ▶ Research Assistant and Teaching Assistant, Department of Economics, and the Institute for Research on Poverty, University of Wisconsin-Madison, 1976-1980
- ▶ Legislative Intern, Office of the Majority Leader, Assembly of the State of New York, Albany, 1976

**Education**

- ▶ University of Wisconsin, PhD, Public Finance & Natural Resource Economics, 1980
- ▶ University of Wisconsin, MS, Econometrics, 1978
- ▶ State University of New York at Albany, BA, Anthropology and Economics, 1976

**Professional Experience**

Dr. Raucher specializes in economic, risk management, strategic planning, and policy analysis as related to natural resource and environmental quality issues. He is a noted expert on water resources management, benefit-cost analysis, and risk assessment, especially as related to public water supply, balancing of multiple uses of watersheds, and policies related to industrial, municipal, and nonpoint sources of water pollution. Selected projects conducted by Dr. Raucher are summarized below:

## **Selected U.S. Engagements in Economics and Risk Management**

### **Quantifying Public Health Risk Reduction Benefits**

1999

Client: American Water Works Association Research Foundation

Dr. Raucher is Principal Investigator for research on quantifying and valuing human health risk reductions associated with reductions in exposure to water-related contaminants. The project emphasizes issues including addressing uncertainty and variability, assessing benefits where threshold-like dose-response functions apply, valuing risk reductions, and presenting stochastic benefit-cost findings in a manner that communicates effectively with decision-makers, legislators, and the general public.

### **Estimating Health Risk Reduction Benefits by Subpopulations**

1999

Client: American Water Works Association

Dr. Raucher is serving as Principal Investigator for research on quantifying human health risk reductions for smokers and nonsmokers under the anticipated drinking water standard for radon. This project emphasizes is in separating risks according to sensitive subpopulations, and to evaluate associated risk reductions in different contexts such as life years saved by group as opposed to simple aggregate measures of total excess mortalities avoided.

### **Estimating the Ecologic Benefits of Superfund Remediation and Site Re-Use**

1999

Client: EPA, Office of Emergency Response and Remediation

Dr. Raucher is managing and helping to conduct assessments of the nonmarket values that are generated as part of Superfund site remediation and with potential types of site re-use that might be developed for sites. The benefits being addressed include nonmarket components of economic welfare (e.g., wildlife associated recreation) and ecologic benefits (i.e., passive use values).

### **Estimating the Benefits of Section 316b Regulations**

1999

Client: EPA, Office of Water, OST

Dr. Raucher is managing and helping to conduct assessments of the anticipated benefits associated with regulations being developed for cooling water intake facilities. Most effort to date has been based on helping to integrate ecologic modeling choices with the economic benefit components of the analysis, and in providing input into issues that are worth guiding case study site selection. On-going and anticipated future effort to focus on outlining specific methods for estimating benefits in case studies.

**Guidance for Utilities on Building Alliances with Watershed Stakeholders**

1999

Client: American Water Works Association Research Foundation

Dr. Raucher is Principal Investigator for this research project to help lay the foundation upon which utilities and water agencies can build effective watershed stakeholder alliances and, hence, make strides toward actualizing Total Water Management. The project's main objective is to provide comprehensive, objective, innovative, and user-friendly guidance that utility managers and staff can use to identify and implement practical tools for building long-term and constructive alliances with stakeholders. The objective is to provide a "tool kit" that contains both *process* and *content* tools upon which to effectively mobilize stakeholder incentives to generate mutually beneficial outcomes. The final product will help the community of water suppliers operationalize water quality and source water protection programs as well as new supply development, conservation, and overall integrated resource planning (IRP).

**Evaluating the *SafeWater Suite* Software to Estimate Water Supply Benefits and Costs**

1999

Client: American Water Works Association, Government Affairs Office

The *SafeWater Suite* (SWS) is computer software that EPA is developing to estimate the regulatory costs and health benefits of setting Maximum Contaminant Levels (MCLs) for various contaminants. Although this software has been under development for a period of years, the drinking water community has had only limited opportunity to review it. Thus, AWWA retained Dr. Raucher to perform a comprehensive evaluation to ascertain the strengths and limitations of the software and, ultimately, the output generated. Dr. Raucher is leading the evaluation of the software's input data requirements, internal consistency, and ability to generate output that provides reliable and informative results with which to objectively evaluate alternative regulatory strategies for water utilities.

**Assessing the Benefits of the AWWA Research Foundation Research Program**

1999

Client: American Water Works Association Research Foundation (AWWARF)

Dr. Raucher is assisting the Research Foundation by providing an assessment of how individual utilities, and the water industry as a whole, have benefited from the research program. The project was based in large measure on a series of site visits to selected utilities, where in-depth interviews were held with key staff from the main departments in each utility (e.g., management, regulatory compliance, operations, engineering, and water quality). The use of pre-visit surveys, plus the on-site interviews, provided considerable insights into the issues that currently are of major significance to the water utility sector. The project also provided insights on what types of services and research topics the Foundation can provide to better meet the evolving needs of the

water utility sector, and to enhance practical research applications at the utility level. A key area of concern for all systems involved was the need to be able to better understand what other utilities are doing, the related benchmarking issue of how well they are doing relative to the best in their field, and the problems of defining standard terminology and creating adjustment factors to facilitate legitimate metric benchmarking comparisons across utilities with different circumstances.

### **Water and Wastewater Service Expansion and Financial Cost Recovery Analysis**

1998

Client: El Paso Water Utilities Public Service Board

Dr. Raucher is helping El Paso Water Utilities (PSB) examine the viability, costs, and cost recovery mechanisms for options to extend water supply and wastewater services to potential growth areas beyond the utility's current service boundaries. Because of the magnitude of capital infrastructure and water resource demands that city annexation and other growth pressures are exerting in the region, the costs of new service will be high relative to existing connections. Dr. Raucher is helping evaluate the options for water supply, developing estimates of the costs of furnishing water and wastewater services, and examining the financial and equity implications of alternative cost recovery and financing mechanisms.

### **Assessing Infrastructure Capital Needs for the Public Water Supply Sector**

1998

Client: American Water Works Association

Dr. Raucher conducted an analysis of the size and distribution of the capital investment needs nationwide (and by region and facility size category) for replacing and rehabilitating water distribution networks throughout the United States. The projections covered the coming 20-year time horizon, and accounted for regulatory and nonregulatory needs for capital outlays. This analysis compiled data from a search of the literature, by surveying various regulated entities, and also by interpreting data from an EPA-sponsored survey (DWNS).

### **Evaluation of EPA's Anticipated Chemical Monitoring Reform Proposal and the Current Total Coliform Rule Monitoring Requirements**

1996

Client: American Water Works Association, Government Affairs Office

Dr. Raucher summarized and evaluated existing chemical monitoring requirements, and the options EPA is considering for revising those requirements. As part of this project, he also evaluated the current monitoring requirements under the Total Coliform Rule. These two aspects

of the project allow for a comparison of the different monitoring needs associated with chronic versus acute exposure levels. Two case studies were developed to enhance the evaluation and comparison of the current and anticipated proposal for monitoring requirements. Dr. Raucher also developed recommendations for improving the cost-effectiveness and target efficiency of monitoring and reporting regimes.

### **Environmental Valuation Research Inventory and Database Development**

1995

Client: U.S. Environmental Protection Agency, Office of Science and Technology

Dr. Raucher directed an extensive effort to identify, assemble, and critically review the available literature on valuing changes in water quality. The project also entailed review and proposed improvements to development of the Environmental Valuation Research Inventory (EVRI), under development by Environment Canada, as a benefits transfer database.

### **Benefit-Cost Analysis and Regulatory Impact Analysis of the Great Lakes Water Quality Guidance**

1994

Client: U.S. Environmental Protection Agency, Office of Policy Analysis and Office of Water

Dr. Raucher provided U.S. EPA with a benefit-cost assessment for the Great Lakes Water Quality Guidance, with a specific focus on benefits of the Guidance's anticipated impacts on pollutant loadings from point source discharges of persistent and bioconcentrating pollutants (e.g., dioxins and PCBs) to the Great Lakes watershed. The benefit-cost analysis encompassed human health risk assessment, recreational benefits, and ecologic/nonuse values.

### **Benefit-Cost Analysis of Water and Land Resource Management Options in the Tennessee Valley**

1989

Client: Tennessee Valley Authority (and other members of the Land and Water 201 program)

Dr. Raucher managed and conducted an economic analysis of the water quality benefits of alternative land and water resource management options for the Land and Water 201 program. The Land and Water 201 program is a regional, multiagency effort to improve agricultural land productivity, improve water quality, and protect human health within the 201 county (seven state) TVA service area. The analysis addressed surface and groundwater issues related to soil erosion, agricultural chemicals, livestock waste management, wastewater treatment, drinking water supplies, and wetlands protection. The study indicated that the human health, recreation, and other benefits of conservation programs will greatly exceed their costs.

**Opportunities for Effluent Trading to Promote Water Quality Improvements**

1989

Client: U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation

Dr. Raucher worked with the Regulatory Reform Staff in reviewing, correcting, and rewriting an assessment of the viability and economic advantage of alternatives to traditional effluent controls at point source dischargers. His research addressed improving dissolved oxygen concentrations in the Delaware River, addressing technical, economic, and implementation issues with the trading options evaluated.

**Selected Engagements in Natural Resource Damage Assessments and Related Litigation Support****Natural Resource Damage Assessment for Cadillac Groundwater Contamination Case**

1993

Client: State of Michigan (Department of Natural Resources, and Office of Attorney General)

Dr. Raucher served as lead economist in assessing the monetary value of damages associated with groundwater contamination originating at an industrial park in northern Michigan. Damages of concern include the tainting (and replacement) of residential wells, potential contamination of the municipality's primary wellfield and water supply, precluded uses of overlying land resources, and potential passive use values. Dr. Raucher also assisted the state in other NRDA cases, including Saginaw Bay and the G&H landfill.

**Natural Resource Damage Assessment for Tenyo Maru Oil Spill**

1993

Clients: Makah Tribal Council; and Ziontz, Chestnut (Law Firm)

Dr. Raucher served as lead economist in assessing the damages sustained by the Makah Tribe, of northwestern Washington state, because of the oil spill resulting from the sinking of the *Tenyo Maru*. Damages of relevance included loss of subsistence and commercial fishing and shellfish gathering, lifestyle and spiritual losses to the Native Americans due to loss of fishing and the oiling of culturally significant resources, and values associated with potential injuries to marine mammals, sea birds, and other wildlife species.

**Natural Resource Damage Assessment for PCBs and other Hazardous Chemicals Released to the Saint Lawrence River Environment**

1993

Clients: State of New York (Departments of Law and Environmental Conservation), the Saint Regis Mohawk Tribe, U.S. DOI (Fish and Wildlife Service), and NOAA

Dr. Raucher managed natural resource damage assessments for PCB, dioxin, mirex, and other contaminants released from Superfund and other hazardous waste sites into the St. Lawrence River environment (and, for a separate confidential case, one of the Great Lakes). As defined under the Superfund statutes (CERCLA and SARA), these assessments identified, quantified, and valued the economic damages caused by the release of these contaminants to the environment.

**Natural Resource Damage Assessment and Litigation Support for Delaware River Spill**  
1993

Clients: State of Delaware (Department of Natural Resources and Environmental Control), State of New Jersey (Department of Environmental Protection), U.S. DOC (NOAA), U.S. DOI (FWS)

Dr. Raucher served as an expert witness (in depositions) and led the State of Delaware's and the State of New Jersey's natural resource damage assessments for injuries incurred as a result of the *Presidente Rivera* oil spill of June 1989. The physical injury and economic damage assessment focused on impacted wetland areas, important fin and shellfish species, and recreational use of the river and shoreline areas. Two federal agencies (NOAA and FWS) were co-trustees in this case, and participated in the review of the NRDA efforts.

**California Water Supply Contamination and Remediation Analysis**  
1992

Clients: Hoberg, Finger, Brown, Cox and Molligan (private Law Firm)

Dr. Raucher served as expert witness (in depositions) and led a team providing expert consultation regarding the technical feasibility and economic cost of alternative means of providing safe drinking water to a California city. The city's current water supply is an aquifer with widespread contamination by agricultural chemicals, and most of the city's wells now draw water that exceed regulatory standards for DBCP. The investigation focused on activated carbon treatment, surface water diversions, and other options for providing the city with water of adequate quality and quantity. The case was settled during trial.

**Natural Resource Damage Assessment of Kennecott Groundwater Contamination Case**  
1991

Client: State of Utah (Office of Attorney General)

Dr. Raucher served as lead economist on a preliminary damage assessment related to the injuries from groundwater contamination originating at Kennecott mining and processing operations along the western Salt Lake Valley of Utah. The value of damages to groundwater resources were estimated using three approaches: loss of value due to impaired water quality, "market" prices for replacement water, and restoration costing via drinking water treatment costing.

**Natural Resource Damage Valuation Assessment for Coastal Oil Spill**

1991

Clients: State of Washington (Department of Wildlife); Environment Canada; and the Province of British Columbia (Ministry of Environment)

Dr. Raucher codirected an assessment of the State of Washington's and the Province of British Columbia's natural resource damage assessment for injuries incurred as a result of the Nestucca oil spill of December 1988. The assessment focused on the nonuse values and restoration costs associated with the loss of over forty thousand seabirds off the northern two-thirds of Washington's Pacific coastline. Cotrustees included the National Park Service and the Fish and Wildlife Service.

**Natural Resource Damage Valuation and Assessment for Mining Impacts in Idaho**

1991

Clients: Coeur d'Alene Tribe of Idaho and U.S. DOI (Bureau of Land Management)

Dr. Raucher served as principal investigator providing expert economic and litigation support services to the Coeur d'Alene Tribe and the federal Bureau of Land Management to provide preliminary assessments of the physical injuries to natural resources and estimates of the economic value of the associated damages due to mining and smelting operations in northern Idaho's Silver Valley mining district. Natural resource damages include the loss of cultural and spiritual values held by the Tribe, as well as subsistence and recreational values.

**Assessing Noncompliance Penalties for Wastewater Discharge Violations**

1989

Client: Holmes, Roberts, and Owens (private law firm)

Dr. Raucher provided expert consultation regarding economic concepts that determine U.S. EPA's noncompliance penalty calculations. He developed alternative scenarios and input parameter values to accurately represent the noncompliance circumstances. Dr. Raucher used the BEN and ABEL computer models, which he originally helped develop and which are now used by U.S. EPA, to derive penalty calculations consistent with the case specifics, and provided expert advice regarding strategies for settlement negotiations and legal proceedings.

**Selected Publications**

"Great Lakes Water Quality Guidance," with E.T. Castillo and M. Morris. *Conduct and Use of Economic Analysis in Environmental Policy*. R. Morgenstern (ed.). Resources for the Future. Washington, DC. 1997.

“Municipal Sewage Sludge Management,” with M. Podar, and S. Burris. *Conduct and Use of Economic Analysis in Environmental Policy*. R. Morgenstern (ed.). Resources for the Future. Washington, DC. 1997.

“Restructuring Small Systems,” with E.T. Castillo, S.J. Rubin, and S.K. Keefe. *Journal AWWA*, January 1997: pp. 65-74.

“Public Health and Regulatory Considerations of the Safe Drinking Water Act.” *Annual Review of Public Health*. 1996. Volume 17: pp. 179-202.

“Integrating Risk Assessment and Economics in Evaluating Drinking Water Standards.” Proceedings of the IAHS/ISS International Symposium, *Assessing and Managing Health Risks from Drinking Water Contamination: Approaches and Applications*, IAHS Press, Oxfordshire, U.K., pp. 63-71, 1995.

“The Economic Value of Groundwater Protection: What are the Benefits, and How Do They Compare to the Costs?” *Geologic Society of America Today*, pp. 183-194, July 1993.

“Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives,” with Ann Fisher, *Advances in Applied Microeconomics*, Vol. 3, V. Kerry, K. Smith, editor, JAI Press, Inc., Greenwich, CT, 1984.

### **Selected Technical Presentations and Reports**

*New Methods for Estimating Recreational Benefits from Effluent Guidelines, Interim Briefing*, with M. Eiswerth. Presented to the U.S. EPA, Office of Water, Washington DC. April 1998.

*Applying Benefit-Cost Analyses to New Regulations under the SDWAA of 1996: Issues and Illustrations*. Presented at the AWWA Annual Conference, Atlanta, GA. June 1997.

*Applying Environmental Economics to Urban Environmental Management*. Presented at a Hanyung University Seminar, Dept. of Economics, Seoul, Korea. October 1997.

*Estimating the National Costs of Compliance with Drinking Water Regulations*. Presented at the Houston Area Technology Transfer Conference, Houston, TX. May 1997.

*The Use of Benefit-Cost Analysis within the Standard Setting Process*. Presented at the AWWA Annual Conference SDWA Implementation Seminar, Atlanta, GA. June 1997.

*Applying Environmental Economics to Urban Environmental Management*. Presented at the Arab Environmental Institute’s “Symposium on Decision Making in Municipal Affairs.” Casablanca, Morocco. November 1996.

*Environmental Economics Workshop*, with B. Hurd. Presented at the Meteorology and Environmental Protection Administration, Jeddah, Saudi Arabia. June 1996.

*Economic Evaluation of Environmental Impacts*. Sponsored by the Asian Development Bank, hosted by the National Institute of Public Administration (INTAL). Kuala Lumpur, Malaysia. March 1996.

*The Benefits of the Foundation's Research Programs*. Presented to the Board of Trustees, AWWA Research Foundation. San Antonio, TX. February 1996.

*A Screening Approach for Setting Research Priorities for Reviewing EPA's Development of Maximum Contaminant Levels*, for American Water Works Association — Research Foundation, March 1989.

*Emerging Issues Affecting Superfund Liability and Remediation Costs: Natural Resource Damage Assessment*, presented at the Hazardous Waste Superconferences, April and May 1988.

*The Risk Tradeoffs of Chlorinating Drinking Water: An Evaluation Based on Risk Attributes and Perceptions*, presented at the Eastern Economics Association Meetings, March 1988.

*An Evaluation of the Conservation Reserve Program's Impact on Water Quality*, for U.S. Environmental Protection Agency, Office of Policy Analysis, January 1988.

*Meeting Water Quality Goals on the Delaware River: A Preliminary Assessment of Feasibility and Cost*, for U.S. Environmental Protection Agency, Regulatory Reform Staff, November 1987.

*The Role of the Conservation Reserve Program in Funding State Nonpoint Source Management Program*, for U.S. Environmental Protection Agency, Office of Policy Analysis, May 1987.

*Applying the Concepts of Risk Management to Wellhead Protection Area Programs: A Preliminary Assessment*, for U.S. Environmental Protection Agency, Office of Ground-Water Protection, March 1987.

### **Professional Affiliations and Awards**

- ▶ Member, National Drinking Water Advisory Council, Benefits Work Group (AWWA Representative)
- ▶ Member, Risk Management Technical Advisory Workgroup (TAW), and Economics TAW, American Water Works Association
- ▶ Editor's Citation for Excellence in Refereeing, *Water Resources Research*, 1994
- ▶ Lead author for "Best Paper" in the *Journal American Water Works Association*, 1993 and 1996

- ▶ Referee, Land Economics, Water Resources Research, American Economic Review, Journal of Environmental Economics and Management, Journal American Water Works Association
- ▶ Silver Medal for Superior Service, U.S. Environmental Protection Agency, 1982
- ▶ Co-Winner, The Abt Associates Award for Research in Public Policy, 1980
- ▶ Member, American Geophysical Union, American Water Works Association, Water Environment Federation

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