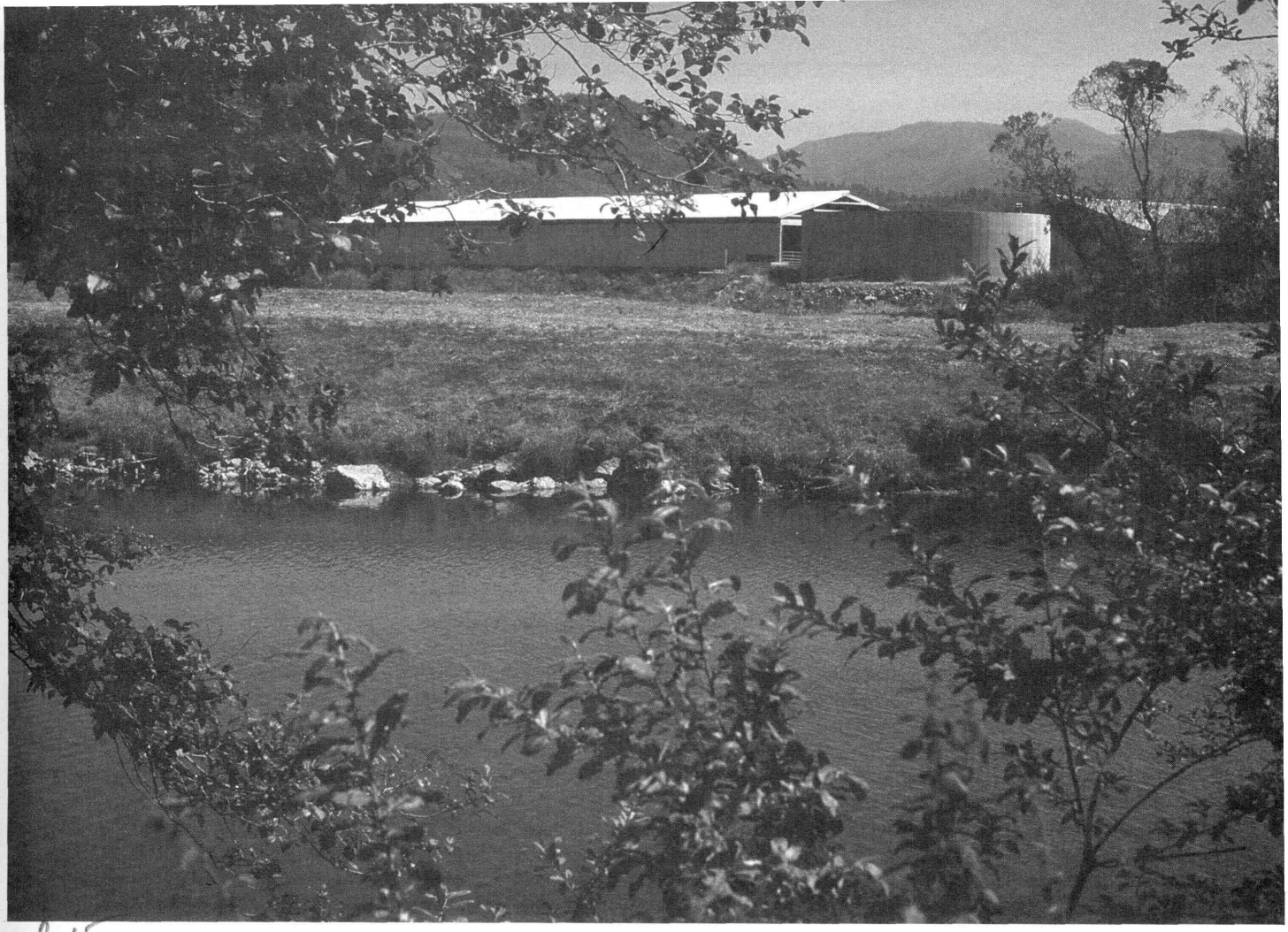

Benefit and cost insights from the Rural Clean Water Program

By Steven Piper, C. Edwin Young, and Richard Magleby

SCIENTISTS generally label agriculture as a major contributor of nonpoint-source water pollution in the United States (2). Runoff from agricultural land can carry sediment, nutrients, bacteria, and pesticides to downstream water resources. In addition, nutrients and bacteria from agricultural activities can contaminate groundwater supplies. These residuals degrade water quality and impair water-related recreation, water supplies and treatment, commercial fishing, water storage, aquatic habitats, and aesthetic qualities. Using best management practices (BMPs) on agricultural land, nonpoint-source pollution and related water use impairments can be reduced.

We evaluated the experimental Rural Clean Water Program (RCWP) from the standpoint of the likely level of economic benefits and costs that might accrue from reducing agricultural nonpoint-source pollution. We identified project characteristics that contribute to high, moderate, and low or uncertain gross and net benefits. Our analysis is speculative because the program is not fully completed and water quality impacts and changes in water use at each project location are still being documented. But we believe the study provides insights and guidance for future nonpoint-source control programs, such as the $400 million nonpoint-source federal grant program included in the Water Quality Act of 1987.

Some background on RCWP

RCWP was initiated in 1980 to demonstrate the effectiveness of improving water quality using agricultural land management practices. The program is administered by the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA). It includes 21 projects, one of which is currently inactive. Four activities are associated with each project: government cost-sharing for implementing BMPs, technical assistance to help farmers determine appropriate BMPs and assist in implementation, information and education to make farmers aware of RCWP, and water quality monitoring. Cost-sharing provides incentives for farmers to participate in the volun-

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tary program—up to 75 percent of the cost of BMP implementation with a maximum of $50,000 per farm. RCWP is scheduled to be completed by 1991.

As an experimental program, the focus of RCWP was to determine which BMPs would most likely result in improved water quality under different project conditions and provide information for future agricultural nonpoint-source control programs. Although off-site benefits were expected from improving water quality through RCWP, generating high net benefits was not a primary goal of the experimental program.

The 21 projects included in RCWP represent a variety of impaired water uses and problem pollutants throughout the United States. The impaired water uses include recreation, water supplies, water storage, and commercial fishing. Water quality problems at the projects include nutrients, sediment, bacteria, and/or pesticides. Economic conditions in the project areas also vary, affecting BMP contracting and implementation rates. The variation in project characteristics allow comparison of the benefits generated under different project conditions.

Recreation impairments existed at 19 of the 21 projects. Nutrients, bacteria, and sediment can impair recreation through increased algae growth, health hazards, reduced surface water area and depth, and lower aesthetic quality. Water supplies were affected adversely at 11 of the projects, either through increased treatment costs or potential health hazards due to high nitrate levels in groundwater. Groundwater samples at four of the projects showed nitrate levels that exceeded federal water supply standards. Reduced property values from degraded water quality was an impairment for only the St. Albans Bay project in Vermont. However, property value damages could occur at any of the other 20 projects. Unfortunately, property value information is available only for the Vermont project. Wildlife habitat impairments are not indicated for any of the projects because of the difficulty in evaluating the extent of wildlife damages.

Thirteen of the RCWP projects have high nutrient levels causing water use impairments. Sources of nutrients include cropland runoff, animal waste, and municipal sewage treatment plants. Thirteen projects are affected by sediment or turbidity associated with sediment. Nine projects have excess bacteria problems due to animal waste or sewage treatment plants. Only one project, Bayou Bonne Idee in Louisiana, is adversely affected by pesticides. The pesticide problem in Bayou Bonne Idee now appears to be attributed more to past rather than current use.

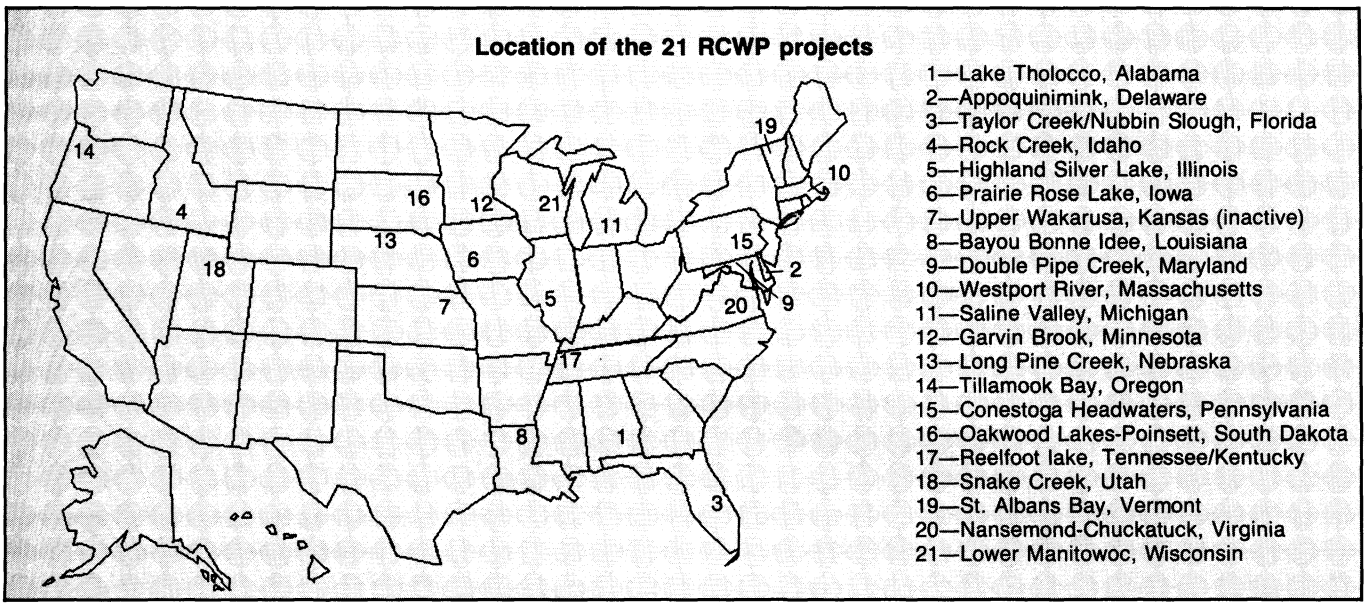
Assessing benefits

After identifying water resource uses and impairments at each project, we estimated the potential benefits that the RCWP project might have for preserving water quality from further deterioration and improving water quality over preproject conditions. We then adjusted the potential benefits to reflect likely changes in water quality and added the two categories together to get total likely gross benefits. The estimated benefits represent a with-RCWP versus without-RCWP comparison. We compared the likely benefits with government costs to determine likely net benefits. Based on the level and degree of certainty for the benefits and costs, we classified projects into high, moderate, low, and uncertain categories. Finally, we compared various characteristics of the projects against these economic classifications to gain insights and guidance for future programs.

Potential preservation benefits. Estimating the benefits of maintaining pre-RCWP water quality required estimates of water use, the value of water use, and the water quality trends before RCWP that may have continued if RCWP had not been implemented. Potential benefits of maintaining pre-RCWP water quality can range from zero at projects where water quality would not have declined without RCWP to the full value of water use at projects where water use would have dropped to zero without RCWP. We estimated the benefits of maintaining pre-RCWP water quality only for recreation and commercial fishing, recognizing that the availability of alternative recreation and commercial fishing sites was ignored. We did not estimate benefits of maintaining water quality for water supplies because water treatment can be used to maintain supplies if water quality declined. Also, reliable information was not available to estimate what sedimentation rates would have been in the lakes without RCWP.

Primary water quality problems and impaired uses at each RCWP project

Project	*Map Number*	*Water Quality Problem(s)*	*Impaired Uses*
Alabama	1	Sediment, bacteria	Recreation, water storage
Delaware	2	Phosphorus, bacteria	Recreation
Florida	3	Nutrients	Recreation, water treatment, commercial fishing
Idaho	4	Turbidity, sediment	Recreation, ditch maintenance
Illinois	5	Turbidity, sediment	Water treatment, recreation
Iowa	6	Sediment, nutrients	Recreation, water storage
Kansas	7	Sediment	Recreation
Louisiana	8	Pesticides, turbidity	Recreation
Maryland	9	Bacteria, turbidity	Recreation, water treatment
Massachusetts	10	Bacteria	Commercial fishing, recreation
Michigan	11	Sediment, nutrients	Recreation
Minnesota	12	Sediment, bacteria, nitrates	Recreation, groundwater supplies
Nebraska	13	Sediment, nitrates	Recreation, groundwater supplies
Oregon	14	Bacteria	Commercial fishing, recreation
Pennsylvania	15	Sediment, bacteria, nitrates	Water supplies
South Dakota	16	Nutrients, sediment	Recreation, water supplies
Tennessee/Kentucky	17	Sediment, nutrients	Recreation, water storage
Utah	18	Phosphorus	Water treatment
Vermont	19	Phosphorus	Recreation, water treatment, property values
Virginia	20	Bacteria, nutrients	Recreation, water supplies, commercial fishing
Wisconsin	21	Bacteria, phosphorus	Water treatment, water depth in harbor, recreation



We estimated the recreational use values for all except the Idaho, Illinois, South Dakota, and Vermont projects by multiplying the number of annual user days times average user-day values for different regions in the United States (*5*). We used survey results to estimate recreational use values at the Illinois (*4*), South Dakota (*9*), and Vermont Projects (*11*). An interim economic evaluation of the Rock Creek, Idaho, project by the Economic Research Service (ERS) was used to estimate the value of recreation at the Idaho project.

We estimated commercial fishing benefits for the Florida, Massachusetts, Oregon, and Virginia projects. Estimated benefits equaled the average annual net revenues from commercial fishing affected by the problem pollutants in the project area over the past five to 10 years.

Potential improvement benefits. Estimating the benefits of improved water quality requires more information than estimating benefits of maintaining pre-RCWP water quality. To estimate potential improvement benefits one needs to determine the response of recreationists, water treatment plants, water storage facilities, and groundwater users to improved water quality.

Our estimates of potential benefits of improved water quality assume water quality would improve to the extent that water quality goals are achieved and impaired water uses are improved at each project. This implies that agriculture contributes a large enough share of nonpoint-source pollution that meeting RCWP project goals will significantly improve water quality and increase impaired water uses. The annual RCWP project reports indicate treatment of agricultural sources of pollution is necessary at all 21 projects to reduce water use impairments. Therefore, benefits generated by improved water quality within the project areas are attributed to RCWP and expenditures made to reduce pollution from other sources, such as updated wastewater treatment facilities, are included in the cost estimates.

Five of the project staffs provided information useful in estimating potential improvement benefits for recreation. At Highland Silver Lake, Illinois, a survey of anglers indicated improved water quality could increase recreational fishing by 55 percent, despite boating limitations on the lake (*4*). A survey of recreationists at Oakwood Lakes/Lake Poinsett, South Dakota, indicated recreational use would increase by 59 percent if algae resulting from excessive nutrients were no longer a problem (*9*). According to the Prairie Rose Lake, Iowa, annual progress reports, nonfishing use of the lake has increased 12 percent since 1981, which could be a result of improved water quality. A recreational survey of St. Albans Bay, Vermont, indicated recreational use would increase 150 percent if water quality improved to the extent that algae no longer caused recreational impairments (*11*). An ERS interim economic evaluation estimated recreational fishing would increase 15-fold in Rock Creek, Idaho, if water quality increased from poor to medium and 5 percent from medium to good. These estimates of increased recreational use from improved water quality were used to derive a range of potential recreational benefits from improved water quality with RCWP compared to water quality if RCWP had not been implemented.

We multiplied the total value of recreation at each project by .12 and 1.5 to estimate a range of potential improvement benefits for recreation. This range of benefits represents the lowest increase in recreational use resulting from RCWP (Iowa) and the second highest increase (Vermont). The 15-fold increase in Idaho was not used as an upper estimate because improving water quality from poor to medium as defined in the Idaho survey may not be an accurate representation of conditions at the other projects. Although the range used to estimate improvement benefits for recreation may not be accurate for all of the projects, it shows the potential impact that improved water quality can have on recreational use.

The potential improvement benefits of reducing water treatment costs were estimated to be equal to the costs of treating pollutants. For example, in the Snake Creek, Utah, project about $4,000 is spent each year to reduce taste and odor problems caused by algae growth. The project goal was to reduce nutrients that contribute to algae growth; therefore, the potential water supply benefits from reducing nutrients in Snake Creek were estimated to be $4,000 per year. We also estimated water treatment benefits for the Taylor Creek, Florida, project and the Nansemond-Chuckatuck, Virginia, project.

The progress reports for the Kansas and Maryland projects indicated that water treatment benefits were expected at these projects from RCWP. However, there was no indication that these two projects would significantly affect water treatment levels.

The benefits of RCWP reducing water treatment costs may be overestimated because some base level of water treatment probably will be continued even though agricultural nonpoint-source pollution is re-

duced. However, the water treatment estimates do serve as a maximum value for water treatment benefits and can be compared with benefits from improving other use impairments at other projects.

We also estimated water supply benefits for the Lower Manitowoc, Wisconsin, project. At the Wisconsin project, heavy rainfall occasionally causes increased bacteria levels where water is drawn for water supplies. As a result, rain collector wells must be maintained as a secondary water supply. The maximum water supply benefits of RCWP were estimated to equal the cost of maintaining these wells, $20,000 annually.

Groundwater sampling at the Minnesota, Nebraska, Pennsylvania, and South Dakota projects indicated that some areas within each project had nitrate levels above federal standards of 10 parts per million. Potential improvement benefits of reducing groundwater nitrate levels were estimated to equal the cost of providing alternative water supplies to those in the project area that may be affected by high nitrate levels. We used the average retail price of bottled water (*1*) as the cost of alternative water supplies in this analysis. We assumed bottled water would be a suitable replacement for contaminated groundwater supplies. The percentage of sampled wells with nitrate levels exceeding federal standards (*6, 7*) was multiplied by the project area population to estimate the population affected by high nitrate levels. We assumed the percentage of wells above federal standards to be a good indicator of the population at risk from contaminated groundwater supplies.

Water treatment and rural water systems are also alternatives for reducing the risks of high nitrate levels. Because the costs of providing treated water could vary substantially and the information needed to realiably estimate costs was not immediately available, we used the cost of providing bottled water. However, the cost of providing bottled water to those with contaminated wells is only a partial measure of the potential benefits of reducing nitrate pollution. There are inconveniences associated with bottled water use, such as transport and storage of bottles, that are not included in the cost of providing bottled water. In addition, benefits of reducing nitrates could be much higher than estimated if health problems associated with high nitrate levels are avoided. Conversely, short-run benefits could be lower than estimated if no adverse health impacts would occur from consuming groundwater with high nitrates or if groundwater quality improvement takes several years due to nutrients held in the soil (*10*).

We estimated the benefits of reducing the rate of lost water storage due to sedimentation by multiplying the reduction in sedimentation rates that have occurred or are projected to occur as a result of RCWP by the cost of dredging sediment that was prevented by RCWP. We used regional sedimentation estimates (*3*) when information was not available from the projects.

We did not estimate benefits for commercial fishing due to the lack of data available to estimate likely improvement in production from improved water quality. Fishing data provided by the Flordia Game and Fresh Water Fish Commission indicated the catch rate in Lake Okeechobee, Flordia, over the last 10 years has been more a function of lake depth than water quality. In addition, the Massachusetts Division of Marine Fisheries indicated shellfish production was not immediately affected by closures of shellfish beds to commercial production because fishing intensity can be increased in the beds that remain open over the short term. As a result, there were not enough data on which to base water quality improvement benefits for commercial fishing.

Likely benefits. We estimated likely benefits using information from the annual project reports; Soil Conservation Service (SCS) and Extension Service personnel familiar with each project; and North Carolina State University National Water Quality Evaluation Project RCWP reviews (*6, 7, 8*), which indicate water quality changes that have occurred or will probably occur as a result of RCWP. The North Carolina review team made several assessments of the RCWP projects, as follows: (a) *water quality improvement to date*—measurable water quality improvement of the impaired water resource that has occurred as of April 1986; (b) *realistic water quality goals*—an assessment of the potential for each project to attain water quality goals if 75 percent of the critical area is treated; (c) *likely water quality improvement*—an assessment of possible improvement considering both the nature of the hydrologic system and the effectiveness of the land treatment activity. This category indicates water quality improvement at the project level that is likely to occur as a result of the RCWP effort.

Contracting rates, the current level of BMP implementation, and the types of practices contracted and installed are used to determine

Criteria for determining likely off-site benefits of RCWP projects

Project	Approximate Percentage of Pollutant from Agricultural Land Within RCWP Project Area*	Percentage of Critical Area Under Contract*	Water Quality Improvement To Date†	Realistic Water Quality Goals†	Water Quality Improvement Likely†
Alabama	75	80	Yes	Yes	Yes
Delaware	30	87	Yes	Yes	Yes
Florida	27	78	No	Yes	Yes
Idaho	100‡	69	Yes	Yes	Yes
Illinois	94	69	No	No	No
Iowa	100	82	No	Yes	Yes
Kansas	100‡	28	No	-	-
Louisiana	100‡	60	No	No	Yes
Maryland	100‡	96	No	No	Yes
Massachusetts	50	22	No	Yes	No
Michigan	100‡	45	No	No	Yes
Minnesota	90	58	No	Yes	Yes
Nebraska	100‡	62	No	Yes	Yes
Oregon	60-80	77	Yes	Yes	Yes
Pennsylvania	100‡	10	No	No	No
South Dakota	100‡	66	No	Yes	No
Tennessee/ Kentucky	100‡	53	No	No	No
Utah	15	93	Yes	Yes	Yes
Vermont	25	76	No	Yes	Yes
Virginia	88‡	69	No	No	Yes
Wisconsin	60	64	No	Yes	Yes

*Source: Annual RCWP progress reports, 1981-1986.
†Source: North Carolina State University National Water Quality Evaluation Project RCWP Cross-Project Evaluation, April 1986.
‡Other minor sources of pollution contribute to water use impairment.

the possibility of water quality improvements taking place. In addition, the contribution of agricultural activities to the pollution problem and the pollution reductions necessary to reduce the water use impairments also were considered. We assigned benefits according to those water use impairments that appear most likely to be improved. The likely gross benefit category can include both maintenance and improvement benefits if the project appears to have halted water quality deterioration and improved water quality compared with water quality if RCWP had not been implemented.

Project benefits and costs

Our evaluation of the benefit and cost levels for each of the projects showed that four of the RCWP projects likely would have high benefits—those in Florida, Oregon, South Dakota, and Vermont. Water quality improvements under current project conditions are expected at all of the four high-benefit projects, except South Dakota. Substantial benefits appear likely for the Oregon and South Dakota projects as a result of RCWP preserving water quality that would have otherwise deteriorated. In each of the high-benefit projects there are specific, documented water quality problems and impaired uses. As a result, BMPs at these projects can be directed toward attaining specific water quality and use improvement goals, increasing the prospect of high off-site benefits.

Moderate benefit levels appear likely for the projects in Alabama, Delaware, Iowa, Minnesota, and Nebraska. Moderate benefits will be generated mostly by likely improvements in water quality over preproject conditions that reduce recreation impairments. Some benefits in the Minnesota and Nebraska projects will also result from improved groundwater quality.

Likely benefits appear low for the Idaho, Illinois, Kansas, Louisiana, Massachusetts, and Tennessee/Kentucky projects. Low benefits result from low use impairment, few impaired users, poor BMP implementation, water resources that are not likely to respond to improved land management practices, or a poor choice of land management practices.

Projects with uncertain benefits include those in Maryland, Michigan, Pennsylvania, Utah, and Virginia. These projects have the potential to generate benefits to major downstream water resources outside of the project area if they become part of a larger regional water quality program. Otherwise, the value of benefits generated by the uncertain projects is low.

The RCWP projects are not necessarily using the most efficient land treatment practices to reduce problem pollutants. Therefore, benefit-cost comparisons of the projects do not necessarily indicate all projects capable of generating positive net benefits. However, comparing benefits and costs does show positive net benefits can be generated through the implementation of agricultural BMPs.

The data used to estimate the level of project costs came from annual project reports and personal communications with SCS and Agriculture Stabilization and Conservation Service (ASCS) personnel familiar with each project. The level of total costs represents acres contracted through 1990, as of the end of 1985. On-site costs and benefits paid for or received by farmers are not included, which leaves the question simply whether the water quality benefits will exceed the expenditure of public funds made to achieve those benefits. Operation and maintenance costs are not included in the cost estimates because they represent private rather than public costs.

Likely level of gross and net economic benefits from RCWP

Project Location	*Benefits from Maintaining Pre-RCWP Water Quality*	*Benefits From Improving Pre-RCWP Water Quality**	*Total Gross Benefits**	*Government Costs**	*Likelihood of Positive Net Economic Benefits*
Alabama	Low	Moderate	Moderate	High‡	Low‡
Delaware	Low	Moderate	Moderate	Moderate	High
Florida	Low	High	High	Moderate	High
Idaho	Low	Low	Low	High‡	Low‡
Illinois	Low	Low	Low	Moderate	Low
Iowa	Low	Moderate	Moderate	Low	High
Kansas	Low	Low	Low	Moderate	Low
Louisiana	Low	Low	Low	High	Low
Maryland	Low	Uncertain	Uncertain	High	Uncertain
Massachusetts	Low	Low	Low	Low	Low
Michigan	Low	Uncertain	Uncertain	High	Uncertain
Minnesota	Low	Moderate	Moderate	Moderate	Moderate
Nebraska	Low	Low/moderate	Low/moderate	Moderate	Uncertain
Oregon	Moderate	High	High	High	High
Pennsylvania	Low	Uncertain	Uncertain	Moderate	Uncertain
South Dakota	High	Low	High	Moderate	High
Tennessee/ Kentucky	Low	Low	Low	High	Low
Utah	Low	Uncertain	Uncertain	Low	Uncertain
Vermont	Low	High	High	High	High
Virginia	Uncertain	Moderate	Uncertain	Moderate	Uncertain
Wisconsin	Low	Uncertain	Uncertain	High	Uncertain

*The level of gross and net benefits is classified as uncertain when additional downstream benefits outside of the project area could be generated if the project becomes part of a larger regional program that preserves or improves water quality in major downstream resources. The benefits within the project areas are generally low.

†Benefits are considered to be high if the range of likely benefits are equal to or greater than $2 million discounted more than 50 years, moderate if between $400,000 and $1.9 million, and low if less than $400,000. The same categories apply for total government costs.

‡Implementation of most cost-effective BMPs could have significantly lowered costs and improved the likelihood of net benefits.

Influences on off-site benefits

Several factors influence the level of off-site benefits likely to result from a reduction in nonpoint-source pollution. These include the number of users affected, the extent of the impairment, the effectiveness in controlling the problem pollutant, the type of pollutant, and the type of impaired use. If several potential projects have users affected by poor water quality and the potential for reducing pollution, the type of water use impairment and pollution problem may be im-

portant in selecting projects with potentially high benefits.

The type of pollutant causing water use impairments may play a role in net off-site benefits. The RCWP projects with higher likely off-site benefits are also predominantly those with likely reductions in nutrients or bacteria entering lakes, bays, or estuaries within or adjacent to the project area. One reason may be that reductions in such pollutants, where they are limiting factors, can more quickly stimulate recreational use than will reductions in sediment. However, the three projects addressing primarily sedimentation problems that have low likely off-site benefits also had implementation problems (Louisiana and Tennessee/Kentucky) or special limitations on recreational water use (Illinois). As a result, the role of the type of pollutant being treated on the level of benefits is at best cloudy.

Likely benefits appear to be lower for water supply impairments than for recreational or commercial fishing impairments. However, if the recreational or commercial fishing activity affected by nonpoint-source pollution is not at a high level, benefits will be low. The level of activity is high and potential benefits are high if lakes or estuaries are adjacent to the project area compared to local stream segments. Recreation is the most frequently impaired use and appears to be the key to potentially high off-site benefits. Groundwater supply benefits are likely to be low because groundwater quality may not respond rapidly to land treatment (*6, 10*). However, over the long term groundwater benefits could be very high due to the relatively high cost of providing alternative water supplies or potential health concerns. Surface water supply benefits are low because water treatment costs appear to change very little even if nutrient or bacteria levels are reduced because chemical treatment costs for these pollutants are a small part of total water treatment costs.

Implementing BMPs to reduce more than one pollutant can result in conflicting water quality impacts. For example, the use of conservation tillage or terraces to reduce sediment may increase nutrient concentrations in the soil, possibly increasing groundwater nitrates (*12*). Surface water benefits may be generated at the expense of groundwater damages. As a result, potential tradeoffs must also be considered when determining the appropriate BMPs to implement at a project.

The costs associated with generating off-site benefits also vary according to the type of pollution problem and the BMPs used to treat the problem. The most expensive BMPs implemented under RCWP include terraces, animal waste management structures, land forming and leveling, waterway systems, sediment retention and water control structures, and improved irrigation and water management. These practices account for more than one-half of the total project costs at 12 of the 19 projects where costs could be separated by BMP. Conservation tillage was the major expense at only three projects and nonstructural nutrient management was not a major expense at any of the projects. If terraces, sediment retention structures, and animal waste storage structures could be successfully replaced with conservation tillage or nutrient management, then the costs of some projects could be reduced substantially.

The RCWP projects do not necessarily represent the most cost-efficient implementation of BMPs. Therefore, net benefits from the 21 projects do not indicate what the benefits could have been if more efficient BMPs had been used. As a result, comparing total benefits is the best indication of project characteristics with potentially high benefits. Cost estiamtes for different BMPs that are capable of meeting water quality goals can then be compared with benefits to chose projects with the highest net benefits.

Any lessons learned?

Although it appears that only one-third and at most two-thirds of the 21 RCWP projects are likely to generate positive net benefits, much has been gained from the program. The different pollution problems, water use impairments, and land treatment practices at each project provide valuable information about the factors leading to high off-site benefits and potentially large net benefits. This information is valuable in targeting areas for future nonpoint-source water pollution control projects. Therefore, as an experimental program RCWP has been successful.

Our analysis indicates that areas with nonpoint-source pollution problems do not necessarily have off-site impacts associated with the pollutants. All of the RCWP projects, with the possible exception of the Upper Wakarusa project in Kansas, have agricultural nonpoint-source pollution problems. However, only about one-half of the projects appear to have substantial off-site water use impairments associated with pollutants in the project area. Without significant impairments, off-site benefits from nonpoint-source pollution control projects are low.

We also found that treating different impaired uses and pollutants can result in different levels of off-site benefits. Projects aimed at reducing recreational and commercial fishing impairments in lakes and estuaries appear likely to generate higher off-site benefits than projects treating water supply impairments. However, reducing nitrates in groundwater may generate high benefits in the long run.

The costs of reducing agricultural nonpoint-source pollution can vary considerably. Therefore, reducing pollutants and improving impaired uses at projects with high potential benefits will not necessarily generate high net benefits. Low-cost, nonstructural practices can be applied in a relatively low-benefit project and result in net benefits, while high-cost structural practices can be applied to a moderate-benefit project and result in net costs.

Lastly, our results are based on what is currently known about each RCWP project. Many of the projects have limited water quality monitoring data and BMP implementation has not been completed, adding further uncertainty to the benefits generated. As a result, our conclusions could change as more water quality data become available and the response of water users to changing water quality can be estimated more accurately.

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