United States
Environmental Protection
Agency

Office of Water
Regulations and Standards Division
WH-585
Washington, DC 20460

February 1988

Water

EPA

NWQEP 1987 Annual Report Status of Agricultural Nonpoint Source Projects

National Water Quality Evaluation Project

NWQEP 1987 Annual Report : Status of Agricultural Nonpoint Source Projects

BY

National Water Quality Evaluation Project
of the
Department of Biological and Agricultural Engineering
North Carolina Agricultural Extension Service
North Carolina State University
Raleigh, North Carolina 27695

In Cooperation With:

U.S. Department of Agriculture
U.S. Environmental Protection Agency

Dr. Michael D. Smolen - Principal Investigator
Dr. Frank J. Humenik - Project Director

Principal Authors

Jean Spooner   Sarah L. Brichford   Richard P. Maas

Contributors

David W. Miller   Alicia L. Lanier   Lane Wyatt

Richard Magleby (USDA-ERS)   Steve Piper (USDA-ERS)
C. Edwin Young (USDA-ERS)

U.S.EPA – USDA Interagency Agreement:
RW-12932650

EPA Project Officer
James W. Meek
Nonpoint Sources Branch
Office of Water Regulations and Standards
Washington, DC

USDA and NCSU Cooperative Agreement:
88-EXCA-3-0853

USDA Project Officer
Fred N. Swader
Extension Service
Agricultural Programs
Washington, DC

February 1988

DISCLAIMER

This publication was developed by the National Water Quality Evaluation Project, a special project of the North Carolina Agricultural Extension Service, sponsored by the USDA and the U.S. EPA under Interagency Agreement RW12932650 through the Cooperative Agreement 88-EXCA-3-0853 between the Agricultural Extension Service, North Carolina State University and the Extension Service, USDA. The contents and views expressed in this document are those of the authors and do not necessarily reflect the policies or positions of the North Carolina Agricultural Extension Service, the USDA, the U.S. EPA, or other organizations named in this report, nor does the mention of trade names for products or software constitute their endorsement.

ACKNOWLEDGMENTS

The authors would like to acknowledge the following persons for their help on different parts of this report: Drs. David A. Dickey and Larry A. Nelson (Dept. of Statistics, North Carolina State University); Gary Ritter and Eric Flaig (South Florida Water Management District); Lynn Hester (USDA-SEA-AR, Southeast Watershed Research Laboratory, Tifton, Georgia); Tom Johengen (Dept. of Atmospheric and Oceanic Sciences, University of Michigan); Monica Wnuk (Iowa Dept. of Natural Resources); and JoAnn Carter and Rosie Coenen (Shelby County ASCS, Iowa).

The authors would also like to thank Naomi Muhammed-Feaste and Terri Hocutt for clerical assistance and Sandy Sullivan for design assistance in producing this report.

Executive Summary

FOREWORD

This report is one in a series of annual water quality reports published by the National Water Quality Evaluation Project (NWQEP) in cooperation with the United States Department of Agriculture and the United States Environmental Protection Agency. NWQEP brings to light current findings and observations from agricultural nonpoint source (NPS) control projects around the country. Particular attention is given to the Rural Clean Water Program (RCWP) projects because RCWP is an experimental program to test voluntary agricultural NPS pollution control. Through analysis of these projects, RCWP lessons can be transferred to other NPS programs and projects now being developed under section 319 of the Water Quality Act of 1987.

The introductory chapter of this report provides an overview of information gained from RCWP in several areas of NPS control. This chapter is followed by brief profiles from the NWQEP data base of the 20 active RCWP projects and three other NPS projects. Each profile covers the project's contributions to NPS control efforts, characteristics and results, and lessons learned about NPS control. The report also features in-depth analyses of three RCWP projects focusing on the detection of water quality improvements in their designated impaired water resource using water quality monitoring and land treatment data.

LESSONS FROM RCWP

- *Target water resources of high economic value* for priority watershed treatment. Water quality alone is often insufficient to measure economic damage or potential economic benefits for selection of NPS control projects. Other important elements are the type and extent of water use impairment, the number of people affected, and the extent to which water quality may improve with NPS control.

- *Identify critical NPS areas within the watershed.* Targeting project resources to critical areas is the most cost-effective approach and allows project managers to set clear goals for NPS treatment within the scope of the project.

- *Treat critical areas with appropriate, cost-effective BMPs.* This implies that the selected BMPs are widely acceptable to project participants and that participants have a sufficient level of expertise to maintain them. A combination of structural and management practices may be needed to meet water quality goals. Project effectiveness, long-term, may benefit from implementation of management practices that farmers are likely to continue. Structural practices to reduce erosion and pollutant delivery require higher cost and commitment to maintenance.

- *Emphasize nutrient management to protect both surface and ground water* from over-application of fertilizers and animal waste. A strong management program should provide cost-sharing and/or technical assistance for soil and manure testing, including soil sampling and testing for available nitrogen. Active I & E programs can effectively promote proper use of animal waste storage facilities for optimal timing of manure nutrient utilization and proper calibration of manure and fertilizer spreaders.

- *Promote farmer participation* through: 1) communication of clearly stated and acceptable purposes and goals; 2) extensive, sustained one-on-one contact between farmers and project personnel; and 3) appropriate incentives (e.g., cost share, technical assistance) to ensure successful levels of BMP implementation in critical NPS areas.

- *Employ a water quality monitoring design* that is appropriate for the pollutants of concern, sources of pollutants (e.g., animals, fertilizers, pesticides), type of impaired water resource (e.g., river, estuary, lake), size of the watershed, and distance of sources from impaired water resource. It is usually beneficial to monitor not only the impaired water resource but also major inflow sources to the resource. Monitoring inflow sources may reduce the time needed to document BMP effectiveness, however, monitoring at the impaired water resource is necessary to document real changes in its water quality. In addition, a knowledge, or estimation, of the water and pollutant budgets for the impaired water resource can provide perspective on where to monitor, how much water quality effect to expect from land treatment, and what monitoring timeframe is reasonable.

- *Follow a rigorous, consistent monitoring protocol* through the pre-, during-, and post-BMP implementation phases of the project. It appears that at least two to four years of pre-implementation monitoring and two to four years of post-implementation monitoring are necessary to document trends in water quality using a grab sample protocol.

- *Account for hydrologic and meteorologic variability as well as land use* changes in the analysis of water quality monitoring data.

FINDINGS FROM ANALYSIS OF SELECTED RCWP PROJECTS

Saline Valley, Michigan

Analysis of the Saline Valley project indicates that most of the phosphorus loading from this project area to Lake Erie is from urban NPS and point sources rather than agricultural NPS. Two important implications of this finding are: 1) International Joint Commission phosphorus loading reduction goals (30%) for this watershed require point source phosphorus removal and urban NPS control; 2) even in predominantly agricultural watersheds, small domestic sewage water treatment plants, if present, are likely to be the main source of phosphorus.

Prairie Rose Lake, Iowa

The 4,568-acre Prairie Rose Lake watershed includes a 215-acre impoundment and 3,648 acres of cropland. Recreational use of the impoundment is impaired by excessive sedimentation, turbidity, and eutrophic conditions. Seventy-four percent of the critical area is considered adequately treated, primarily by terraces.

Analysis of water quality data adjusting for precipitation and chlorophyll *a* shows that lake water clarity was at its best during 1982 and 1983, shortly after the start of RCWP. In subsequent years, however, water clarity has declined and remained at the pre-project level.

Results of our analysis confirm some tradeoff of sediment turbidity for algal turbidity. A precipitation index explained 6 percent of the variability in water clarity and adjustment for chlorophyll *a* concentration explained an additional 26 percent. After correcting for both precipitation and chlorophyll *a*, however, there is no significant improving water quality trend. There is some indication of an association between water clarity and corn acres put into cover crop through PIK and other ACR programs.

Considering the variability observed to date, the lake monitoring scheme should be able to document, as significant, a change in lake water clarity of as little as 20 percent with ten years of consistent monitoring.

Taylor Creek - Nubbin Slough Basin, Florida

The Taylor Creek - Nubbin Slough Basin is located directly north of Lake Okeechobee. The watershed covers 110,000 acres of which 63,109 acres have been identified as critical agricultural sources of phosphorus to Lake Okeechobee. These sources are primarily improved pastures and dairies. BMP emphasis is on stream protection, animal waste management, and grazing land management.

The project has a valuable pre-BMP water quality data base for statistical comparison with post-BMP data. In addition, most of the BMP implementation occurred in 1985 and 1986, allowing for 4 to 5 years post-BMP water quality monitoring. This project should, therefore, be able to document land treatment effects on water quality.

We analyzed water quality monitoring data from in-stream sampling to determine the magnitude of measured concentration change (minimum detectable change, MDC) in TP and OP required to say with confidence that the change is real. High variability in this hydrologic system contributes to a high MDC. The impact of adjustments for precipitation, seasonality, upstream concentrations, and ground water levels on reducing the MDC were investigated. The MDC for TP ranges from 10 to 59 percent with 9 years of monitoring and adjusting for available covariates. MDC was found to be a function of watershed size, precipitation, ground water levels, season, and upstream concentrations.

We found a significant decreasing trend for TP in three subbasins and at the outflow from the project area. These trends appear to be related to land treatment under RCWP and to dairy closures independent of RCWP.

Table of Contents

List of Tables

List of Figures

List of Abbreviations (Terms, Agencies, Programs)

ACP.................... Agricultural Conservation Program
ACR.................... Acres Conservation Reserve (Federal Commodity Program)
AGNPS.............. Agricultural Nonpoint Source Pollution Model
ANSWERS....... Areal Nonpoint Source Watershed Environment Response Simulation (Model)
ARS.................... Agricultural Research Service, USDA
ASCS.................. Agricultural Stabilization Conservation Service, USDA
A.U..................... Animal Unit
BMP(s).............. Best Management Practice(s)
BOD................... Biological Oxygen Demand
CES.................... Cooperative Extension Service
Chl *a*................... Chlorophyll *a*
CL....................... Chloride
CLP.................... Clean Lakes Program, Section 314 of PL92-500
CM&E............... Comprehensive Monitoring and Evaluation
COD................... Chemical Oxygen Demand
CREAMS.......... ChemicalRunoffandErosion from Agricultural Management Systems (Model)
DO...................... Dissolved Oxygen
DP....................... Dissolved Phosphorous
ERS.................... Economic Research Service, USDA
FC....................... Fecal Coliform
FS........................ Fecal Streptococci
HUC................... Hydrologic Unit Code (and Cataloging Unit)
I&E...................... Information and Education Programs
IN........................ Inorganic Nitrogen
JTU..................... Jackson Turbidity Unit
MLRA............... Major Land Resource Areas
MPN................... Most Probable Number/100 ml
NWQEP............ National Water Quality Evaluation Project
NO_3.................... Nitrate Nitrogen
NH_3.................... Ammonia Nitrogen
NPS.................... Nonpoint Source
NTU................... Nephelometric Turbidity Unit
OP....................... Orthophosphate
PL-566................ Watershed Protection and Flood Prevention Act (PL83-566)
PLUARG.......... Pollution of the Great Lakes from Land Use Activities, Reference Group
RCWP................ Rural Clean Water Program
SCS..................... Soil Conservation Service, USDA

Section 108a......Section 108a PL92-500; USEPA Pollution Control Demonstration in the Great Lakes Basin
Section 208........Section 208 PL92-500; Planning for Wastewater Management
Section 319........Section 319 Water Quality Act of 1987
STORET...........EPA Storage and Retrieval Data Base for Water Quality
STP....................Sewage Treatment Plant
TC.......................Total Coliform
TDS....................Total Dissolved Solids
TKN...................Total Kjeldahl Nitrogen
TN......................Total Nitrogen
TP.......................Total Phosphorus
TSS.....................Total Suspended Solids
TVS....................Total Volatile Solids
USLE.................Universal Soil Loss Equation, Wischmeier & Smith, 1965.
USDA................United States Department of Agriculture
USEPA..............United States Environmental Protection Agency
USGS.................United States Geologic Survey
VSS....................Volatile Suspended Solids
WATSTORE....USGS Water Data Storage System

RCWP PROJECT NAME ABBREVIATIONS

AL-RCWP........Lake Tholocco, Alabama
DE-RCWP........Appoquinimink, Delaware
FL-RCWP.........Taylor Creek - Nubbin Slough, Florida
IA-RCWP..........Prairie Rose Lake, Iowa
ID-RCWP.........Rock Creek, Idaho
IL-RCWP..........Highland Silver Lake, Illinois
TN-RCWP........Reelfoot Lake, Tennessee/Kentucky
LA-RCWP........Bayou Bonne Idee, Louisiana
MA-RCWP.......Westport River, Massachusetts
MD-RCWP.......Double Pipe Creek, Maryland
MI-RCWP.........Saline Valley, Michigan
MN-RCWP.......Garvin Brook, Minnesota
NE-RCWP........Long Pine Creek, Nebraska
OR-RCWP........Tillamook Bay, Oregon
PA-RCWP.........Conestoga Headwaters, Pennsylvania
SD-RCWP.........Oakwood Lakes - Poinsett, South Dakota
UT-RCWP........Snake Creek, Utah
VA-RCWP........Nansemond - Chuckatuck, Virginia
VT-RCWP........St. Albans Bay, Vermont
WI-RCWP.........Lower Manitowoc, Wisconsin

Chapter One Overview

Focus on RCWP

INTRODUCTION

The Rural Clean Water Program (RCWP) is an experimental program to evaluate the social, economic, and technical aspects of controlling agricultural nonpoint source (NPS) pollution. Of the 21 original RCWP projects started in 1980 and 1981, 20 remain active in 1987 providing valuable experience and information for other NPS projects and programs (Figure 1.1). Analysis of RCWP progress as of October 1986 gives insight into factors that promote or inhibit land treatment programs, practices that improve water quality, and costs and benefits attributable to BMPs and NPS pollution control.

Unlike most NPS control projects, RCWP projects include water quality monitoring to evaluate and document their impact on the quality of their designated water resources. Each project has produced a substantial body of information including detailed documentation of the water resource use impairments, planning and development of the land treatment program, description of the monitoring program, and documentation of the water quality monitoring results. Profiles of each RCWP project and other NPS projects in the NWQEP data base are presented in this NWQEP annual report. Together the RCWP projects encompass the most comprehensive body of information yet available on NPS control.

LAND TREATMENT

Targeting Critical Areas

Targeting best management practices (BMPs) to critical areas, areas where land treatment is likely to provide the greatest improvement of the designated water resource, is an essential component of any NPS control project. Targeting provides a framework for setting clear achievable goals and focuses project resources on the most important sources of pollutants.

Analysis of RCWP projects indicates that thorough pre-project assessment to identify critical areas accurately is very important. Although all RCWP projects were expected to identify their critical area at the start of the program in 1980, few guidelines were available at that time. Individual projects have since developed practical guidelines for selecting critical areas. These have been analyzed previously by NWQEP (Maas et. al., 1987).

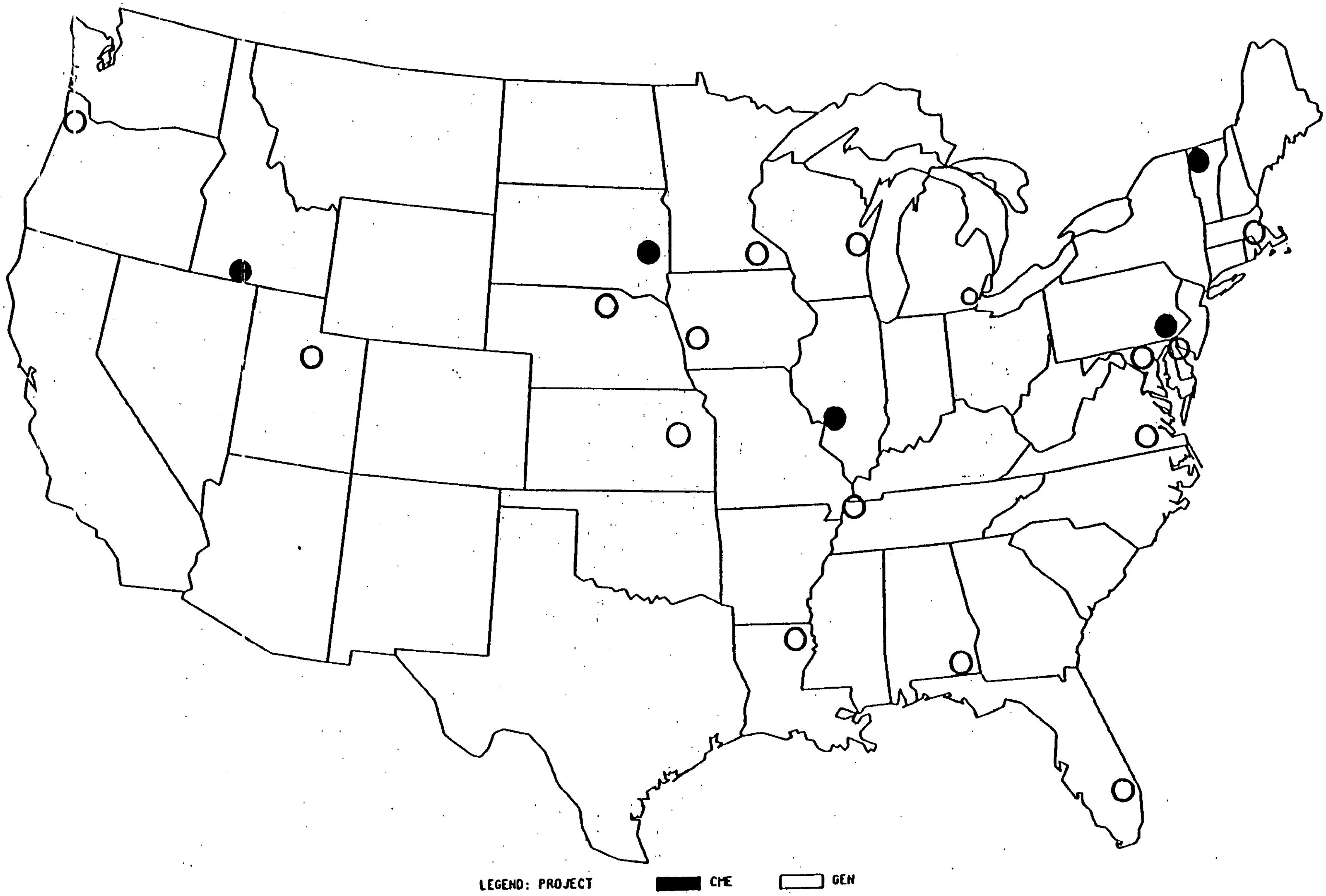


Figure 1.1 Locations of RCWP Projects

Specific criteria and methods for selecting critical areas used by RCWPs reflect differences in water use impairments, pollution sources, and land treatment needs. Many projects have refined their selection criteria, and some have designated new or additional critical areas since the program began. Several projects changed critical area boundaries or definitions to adjust for new project goals or spending available monies. For example, the Virginia RCWP expanded its critical area in 1985 because the project felt it had done all it could within the original critical area but had land treatment funds remaining. Three years after the program began, the Minnesota RCWP essentially started a new project, redefining its critical area to focus attention on ground water protection instead of sedimentation of a trout stream. Ground water contamination is more clearly perceived as a problem by project area residents.

The importance of balancing administrative discipline with flexibility is an important lesson to be learned from the RCWP experience. Critical area selection must be flexible enough to allow for changes in water quality objectives and integration of new information that becomes available as the project develops. However, such flexibility should be exercised with care because it can confound analysis and complicate progress reporting. It is even more difficult than usual to relate water quality changes to land treatment if the project's goals and records of progress toward those goals are unclear because of major changes.

Carefully selected critical area selection criteria are important for overall project success, however, the criteria must be applied with consistency to be fully effective. Detailed information about how project managers have applied the selection criteria helps in managing the project efficiently and evaluating progress toward implementation goals. Furthermore, if such information is not available and water quality improvement is not observed, then selection criteria may falsely be judged inappropriate. Analysis of selection criteria can be improved by detailed information about application of the criteria. The best information of this kind is gained from projects such as the Oregon RCWP that have been very specific in describing the application of critical area selection criteria.

Finally, the targeting approach is not immune to the problems inherent in using a voluntary cost-sharing approach to gain farmer participation in NPS projects. Voluntary participation provides no means of ensuring that the targeted population will enter into BMP contracts in a timely fashion. An insufficient level of BMP installation in the targeted critical areas would defeat the purpose of targeting. Thus, overall effectiveness of targeting can be strengthened by careful selection of appropriate BMPs and cost share levels, and an active I & E program to promote interest in and identification with project goals.

BMP Effectiveness

An effective land treatment program is dependent on widespread adoption of the BMPs by farmers within the targeted project area. Extent of BMP adoption may be as important as the mechanical effectiveness of an individual BMP. Even the most effective practices will not improve the quality of the impaired water resource unless there is sustained correct use and maintenance of the practices and a sufficient level of adoption. Thus, project activities that increase the receptivity of area farmers to BMPs (i.e., well developed I & E programs and personalized technical assistance) are needed to increase BMP adoption and promote overall BMP effectiveness.

Documenting the effectiveness of specific BMPs using water quality data is difficult in large projects like the RCWPs. To date, the best demonstration of effectiveness comes from projects where excess animal waste and animal access to watercourses were the primary causes of water quality impairment. Fecal coliform concentrations in surface waters have been reduced significantly in several projects where waste management and fencing BMPs were installed (Florida, Utah, Oregon, Vermont RCWPs). Significant reductions in phosphorus concentrations have been observed in Florida and Vermont RCWPs after treatment of dairy wastes, indicating the importance of such sources and the potential water quality benefits available from treatment. These results suggest that, where phosphorus or fecal coliform bacteria is a problem, dairies should be targeted early.

Models are useful to assess BMP effectiveness and may provide the only way to estimate reductions in pollutant loadings (e.g., tons of soil saved, kilograms of phosphorus prevented from reaching the impaired water resource). Such estimates, however, may be difficult to translate directly into improved water quality. Models only provide an estimate of BMP effectiveness in the context of our current understanding; they cannot account for all factors and cannot predict the future. Models being used in RCWP include USLE, AGNPS and CREAMS. All must be calibrated for site-specific conditions, and their use should complement the analysis of water quality monitoring data.

Overall, measuring BMP effectiveness has been hampered in RCWP by inconsistencies in reporting implementation goals and accomplishments. Many projects do not distinguish clearly between those BMPs under contract and those installed. Also, some projects do not account for pre-RCWP or non-RCWP activities. This makes it difficult to tell whether observed changes in water quality are attributable to RCWP. Reporting procedures have been addressed previously (Dressing et. al., 1984) and should be studied further.

For progress reporting, some projects have divided their watersheds into subbasins to improve BMP accounting. This has two important advantages for project management: 1) BMP accounting by subbasin matches the BMP implementation data with the corresponding water quality monitoring stations; 2) subbasin accounting gives a more accurate and detailed spatial representation of progress toward project goals. Subbasin accounting can be very helpful, especially for large projects with a complex mixture of physical settings and intensive land uses. Subbasin reporting is being used effectively by the Idaho, Virginia, Vermont and Florida RCWPs.

BMP Selection

Determining which BMPs are most appropriate for a particular objective depends on the water resource and its use impairments, the acceptability of the BMPs to farmers in the project area, the economic condition of the farm community and the farmer's level of technical expertise. RCWP experience shows that involving the farmers in design and selection of BMPs improves the farmers' acceptance of BMPs. A combination of structural (e.g., animal waste handling facilities, sediment basins) and management (e.g., conservation tillage, nutrient management) practices may be needed to meet project objectives. The relative importance of structural versus management practices varies from project to project, however, management practices have been receiving increasing attention in recent years.

In the Idaho RCWP, sediment concentrations in irrigation canals have decreased significantly since structural devices (e.g., sedimentation basins and irrigation management systems) were implemented. This result suggests that such practices are quick and effective, and prevent sediment and phosphorus from reaching Rock Creek. However, structural devices such as settling basins do not correct the problem of on-site erosion and can be costly to maintain. The Idaho project is now promoting conservation tillage as the preferred BMP because it is perceived to be a cost-saving practice in which maintenance costs are offset by benefits to the farmer.

The debate on whether or not conservation tillage can be as effective as retention devices in preventing sediment from reaching Rock Creek is currently open. Field research in the Rock Creek area indicates that no-till practices in a cycle of crop rotation can reduce erosion rates by 80% or more and minimum tillage can reduce erosion by 60-85%, with no significant change in crop yields (Carter, 1987). In an area like Idaho, however, where farmers employ 8 to 14 tillage operations each year, conservation tillage requires drastic changes in farming practices. Therefore, a great deal of I & E and technical assistance is needed. Economic analysis shows conservation tillage to be a more cost-effective practice than sediment retention structures for the Rock Creek project (Magleby, 1987), but wide-scale acceptance has not yet been achieved.

The timeframe in which the success of selected BMPs is judged depends greatly upon the type of water resource in which a response to land treatment is being measured. For example, although terracing was implemented extensively (~80% of eligible area) in the Iowa RCWP, no improving trend in the water quality of Prairie Rose Lake has been documented after six years of monitoring. In comparison to the Idaho RCWP, the Iowa RCWP may not be showing a water quality impact because the response time of the lake is longer than that of irrigation canals or because natural variability in the lake system is greater than the water quality change induced by BMPs.

BMP Impact on Quality of Subsurface Flow

Some BMPs, such as terracing and conservation tillage, may increase the rate and volume of nutrients and pesticides infiltrating to ground water. This issue has largely been ignored by RCWP. To document pollutant transport in subsurface flow, elaborate and expensive monitoring is needed such as that in the South Dakota and Pennsylvania projects. Most RCWPs were not designed with this in mind and do not have the needed monitoring budget.

In projects where nutrient contamination of ground water has been documented (South Dakota, Minnesota, Nebraska, and Pennsylvania RCWPs), efforts have been made to evaluate the extent of contamination. Abandoned wells and sinkholes were among the first areas designated critical when the Minnesota RCWP expanded its critical area to address ground water contamination. The project has since learned from research in an area with similar karst topography (Big Springs Basin, Clayton County, Iowa) that sinkholes and abandoned wells may be relatively unimportant entry points to ground water compared to either infiltration base flow or diffuse flow (Garvin Brook RCWP, 1986 Progress Report). Certain soils can retain large amounts of nutrients that are leached at a fairly constant rate. This nutrient reservoir may keep pollutant concentrations in ground water high for many years. It is an extremely complex undertaking to determine how large the reservoir is, at what rate it is leaching and where the nutrients are going. The South Dakota RCWP has found that glacial till within the project area, previously thought to be a barrier to leaching of nutrients, is nearly as effective a conduit for contaminant infiltration as the more permeable outwash soils.

NUTRIENT MANAGEMENT

Awareness of the potential damage to surface and ground water from over-application of nutrients focuses attention on nutrient management as an important BMP. Concern is particularly high where animal manure production exceeds crop or pasture nutrient needs, and where soil and landscape features promote rapid flushing of applied nutrients into the impaired water resource. These conditions predominate in several RCWP projects (Pennsylvania, Florida, Vermont, Virginia, Minnesota, Nebraska, South Dakota, Utah and Oregon).

Some of the projects have strong nutrient management programs in place. In the Pennsylvania RCWP, for example, Extension Service personnel are actively pursuing one-on-one contacts with project area farmers to assist them with nutrient management decisions and to prepare tailored nutrient management plans. This information and education effort has been welcomed by farmers where formal contracts for animal waste management BMPs were previously rejected because of cultural differences. A similar Extension program is proposed for the Virginia RCWP with the following objectives: 1) to match fertilizer application rates to soil test results; 2) to improve timing of fertilizer application to maximize plant utilization; and 3) to improve analysis and accounting of nutrient sources such as manure and legume crops.

We propose the following elements to develop a strong nutrient management program for improving water quality. The recommendations are intended to utilize the most advanced technology accessible and to provide a framework for reporting progress.

1. Survey watershed landowners for current practices, attitudes, knowledge, awareness and skills in nutrient management.
   Use this information to:
   a) estimate the range of soil fertility and crop nutrient requirements;
   b) identify the distribution of nutrient sources and utilization areas for potential nutrient redistribution from areas of oversupply to areas of undersupply; and,
   c) estimate how much improvement in nutrient management can be accomplished given current practices in the watershed.
2. Provide cost sharing or technical assistance for soil testing, including soil sampling and testing for available nitrogen (field or laboratory test). Provide the same assistance for manure testing.
3. Estimate nutrient mass balance for each field, each farm, and for the project area.
   Example for dairy or mixed livestock project area:
   IN: feed, fertilizer
   OUT: milk, meat, crops, excess manure
   RECYCLE: manure, crop residue
   Use this information to determine current nutrient inputs for the area generating pollutants, or for each field in the case of a small project area. Compare with required nutrient needs of crops and pasture based on soil test results, soil type and land form. Adjust nutrient applications accordingly.
4. Use worksheets and written plans to formalize records of nutrient input requirements and application rates for individual farm operations and fields. Where possible, plans should identify the range of susceptibility of ground and surface water to nutrient over-application based on soil type and land form.

5. Provide educational materials, field demonstrations and technical assistance on the calibration of manure and fertilizer spreaders.
6. Establish demonstration plots to show:
   a) the nutrient value of animal waste;
   b) advanced fertilizer application techniques such as banding, split application, and injection or improved incorporation;
   c) use of legume cover; and
   d) other practices of local applicability.
7. Promote the effective use of animal waste storage facilities for optimal timing of manure nutrient utilization.
8. Promote plant tissue testing to determine proper nutrient requirements and to verify recommended nutrient applications.

Changes in management practices often conflict with traditional farming methods. Using commercial fertilizers for insurance with animal waste is a difficult practice to break. Experience from the Pennsylvania RCWP, however, shows that educating farmers about soil testing, crop nutrient needs, proper application rates, and optimal timing can be accepted and may significantly reduce excessive application of nutrients on cropland. Improved nutrient management appeals to farmers as an efficient way to manage farm costs. In the SD-RCWP, results of analysis using the AGNPS model suggest that better incorporation and split application of commercial fertilizer would be very cost effective practices in reducing nutrient loadings to local lakes.

We feel that estimating nutrient budgets at the farm and project levels can help determine the magnitude of the problem and the best approach to its solution. Projects could use an accounting-based system to identify with greater accuracy the amount of nutrients imported (e.g., commercial fertilizer and feed), the amount of nutrients exported via the hydrologic system (e.g., excess fertilizer and animal waste), and the amount of nutrients trapped in sinks (repositories in the soil profile) within the project area. This type of information is essential to develop a project-wide strategy for improving nutrient management.

FARMER PARTICIPATION

Experiences from RCWP point to the following recommendations to strengthen farmer participation in voluntary NPS control projects. The NPS project should have:

- clearly stated and acceptable purposes and goals.
- extensive, sustained one-on-one contact between farmers and project personnel.
- appropriate incentives (cost sharing, technical assistance) to allow targeting of practices to critical areas.

Several RCWP projects have shown that the voluntary approach to NPS control can be effective even in large project areas or depressed economies, although others have found these to be insurmountable obstacles. BMPs must be acceptable to farmers in the project area and incentives such as cost share rates must be high enough and the technical assistance available for implementing the practices.

In some projects regulatory authority has supported the voluntary incentive- based BMP implementation program, assuring participation sufficient to control NPS. The Florida and Oregon RCWPs have regulatory powers that can be invoked, a "threat" that seems to be an important incentive for farmers to participate in the RCWP.

WATER QUALITY MONITORING

Documenting Real Water Quality Changes

Visual, random observations of changes in the state of an impaired water resource do not necessarily reflect statistically significant water quality changes. RCWP is a unique NPS control program in that all projects conduct water quality monitoring to document statistically their impact. The investment in detailed water quality monitoring is intended to allow other non-RCWP NPS projects to proceed with a land treatment program with little or no monitoring.

RCWP has documented improving water quality trends in several projects to date: Rock Creek (Idaho), Snake Creek (Utah), St. Albans Bay (Vermont), Tillamook Bay (Oregon), Appoquinimink River (Delaware), Highland Silver Lake (Illinois), and Taylor Creek-Nubbin Slough (Florida). These projects have maintained a consistent monitoring program that started before the land treatment program and will extend beyond the time when land treatment is essentially complete.

Both the Idaho and Utah projects had two or more years of pre-BMP monitoring data and were able to document water quality improvements with two years of post-BMP monitoring. The Vermont project demonstrated the effect of manure management in a paired watershed experiment. The Oregon project documented water quality improvement after an intensive implementation program to control dairy waste. Lastly, the Appoquinimink River project in Delaware attributed a decrease in total phosphorus concentration to intensive BMP implementation.

Several projects expect improvements in the quality of their impaired water resources but have not yet been able to substantiate their perceived improvement with statistical analysis. For instance, the Highland Silver Lake (Illinois) and Prairie Rose Lake (Iowa) RCWPs have estimated substantial reductions in erosion using models, however, neither project has yet confirmed improved water quality at the lake. (The Illinois RCWP has documented improving trends at gage sites in the watershed.) More time may be needed before the lakes respond to BMP implementation in the watersheds. Similar problems characterize the Lake Tholocco (Alabama) and Reelfoot Lake (Kentucky - Tennessee) RCWPs, i.e., both are large watersheds where improvements in the impaired water resource may be very slow. It appears that even small lakes require a considerable time to respond to BMP implementation in the watershed.

Monitoring Timeframe

The monitoring period needed to document water quality change is generally longer than the time in which the water resource responds to land treatment. This is mainly due to hydrologic and meteorologic variability, and the need for pre- and post-implementation data to confirm the change. Monitoring in the various water resources encompassed by RCWP helps to quantify and predict the response of different water resources under different land treatment schemes.

RCWP project results from Idaho, Utah, and Vermont indicate that water quality changes are quickest where flushing rates are high as in streams and irrigation canals, however, hydrologic variability in such systems is also high. Streams and irrigation canals are generally smaller and more uniform hydrologically than impoundments, bays, estuaries, and rivers. In addition, BMP implementation is generally located closer to lower order streams and canals because these run close to pollutant sources (i.e., through or near livestock pens, erosive fields, dairy facilities) on individual farms where BMP contracts are installed. Monitoring, too, in headwater streams may be less confounded by unknown factors than downstream.

For the most part, RCWP projects treating impairments caused by animal waste show greater water quality improvement in a shorter time than those treating vast acreages of cropland. This is likely due to the resemblance of animal operations to point sources of pollution — their locations are easily targeted for BMPs and monitoring stations. Furthermore, fencing animals out of streams and controlling barnyard runoff are highly effective practices to reduce surface water phosphorus and nitrogen concentrations in a fairly short time (1-2 years in Vermont RCWP and 5 years in Florida RCWP). Control of sediment and associated pollutants is more difficult because all, or at least a large percentage, of the critical area must be treated before water quality changes can be expected. This suggests that more BMPs must be contracted and implemented in projects where cropland treatment is the focus.

It is important to remember that RCWP has a 10-year monitoring timeframe which may be inappropriate for documenting water quality changes in some projects. It is our strong feeling that monitoring should not be discontinued prematurely, regardless of whether or not the project expects to improve water quality within the experimental RCWP period. Gaps in the monitoring sequence hamper data analysis. Without continuous monitoring, it is difficult to tell if a water quality trend (above and beyond system variability) exists or if observations represent random unrelated events. If significant water quality improvement is not observed, one must conclude there is no impact of BMPs, the monitoring timeframe was not long enough, or the monitoring design not sensitive enough to detect the impact.

Monitoring Design and Sensitivity

Much of the good work that goes into an NPS project is wasted if the monitoring design is not appropriate for the application. The crucial first step in developing a successful monitoring program is to make sure that all water quality impairments are documented and all potential sources are clearly identified. Design of the monitoring program should consider the pollutants of concern, sources of pollutants (e.g., animals, fertilizers, pesticides), type of impaired water resource (e.g., river, estuary, lake), size of the watershed, and distance of sources from impaired water resource. It is usually beneficial to monitor not only the impaired water resource but also major inflow sources to the resource. Monitoring inflow sources may reduce the time needed to document BMP effectiveness, however, monitoring at the impaired water resource is necessary to document real changes in its water quality.

Once the monitoring program is underway a rigorous, consistent monitoring protocol should be followed through the pre-, during-, and post-implementation phases of the project. Changes generally reduce confidence levels by confounding the analysis. Uniformity and consistency in data collection, reporting and analysis are essential.

It appears that a minimum of two to four years of pre-implementation monitoring followed by two to four years of post-implementation monitoring is necessary to document real trends in water quality using a grab sample protocol. Other protocols (i.e., paired watershed monitoring, automatic sampling) may increase the sensitivity of documenting real changes.

Minimum detectable change (MDC) is an important concept that can help projects determine how much change in water quality must be measured to be considered a documented real change. MDC is the change in parameter concentration required for statistically significant results. As developed by Spooner et al. (1985, 1986, 1987), at least a 20% to about 60% improvement in water quality of the impaired resource (above the water quality level measured prior to land treatment) must be obtained to be considered significant. Thus, small changes in water quality (less than 20% improvement) may be masked by natural variability in the system.

Hydrologic and meteorologic system variability exerts a strong influence on the water quality data from any water resource. The more information one has to account for system variability and the variability of pollutant sources in the analysis, the smaller is the change needed for statistical significance. It is generally helpful to adjust for factors such as precipitation and flow of surface and ground water. Collecting such coincident hydrologic, meteorologic, and chemical data at each water quality sampling event helps to distinguish real water quality changes from background noise by accounting for the effect of factors that mask the real changes.

The inertia, or resistance to change, in a watershed-water resource system also makes it difficult to detect water quality changes attributable to land treatment. Chemical buffering capacity, dilution, and the interaction of organisms with their aquatic environment tend to compensate and mask changes in water quality. Water quality improvement is often difficult to detect because large nutrient reservoirs in the soil profile or in lake sediments keep the supply of nutrients nearly constant and mask the effect of BMPs by continually replenishing nutrients from the reservoir. Other factors contributing to system inertia and "steady-state" conditions include large watershed area, slow flushing rates, past land uses which stockpiled animal wastes or fertilizers, and artificial manipulations of flow such as the operation of dams. These factors must be assessed on a site-specific basis to evaluate potentially the system's response to land treatment.

We feel that an appropriate first step in watershed analysis is to develop water and pollutant budgets for the impaired resource. This provides perspective on how much water quality effect to expect from land treatment and what monitoring timeframe is reasonable. For instance, in the Idaho RCWP, the project area contributes only about 25% of Rock Creek's total flow; thus, a large reduction in NPS pollutants entering Rock Creek from the RCWP is likely to yield only a small change in Rock Creek's water quality. This points up the fact that even if the project were 100% effective in controlling NPS, the expected effect on Rock Creek's water quality could be small.

Similarly, the Florida RCWP has documented that flow from the project area comprises only 4% of the total inflow to Lake Okeechobee but 27% of the total phosphorus input to the lake from all sources. Thus, 73% of the phosphorus, a very large amount, comes from areas outside the project area. Furthermore, Lake Okeechobee contains many years' effluent from the RCWP project area. The project has recognized from the start that many years of monitoring would be required to document any change in the lake and chose to monitor the outlet from the project area instead of the lake. As a result, the project has documented decreasing phosphorus concentrations in project area outflow, but the relative impact of this decrease is far overshadowed by the large percentage of phosphorus coming from sources outside the project area.

ECONOMIC EVALUATION OF RCWP[1]

Economic evaluation of RCWP provides valuable insight into the economics of reducing nonpoint pollution from agricultural sources. Economic aspects evaluated for future program guidance include cost-effectiveness of particular BMPs, incentives to participate, and benefits versus costs of individual projects. For each project, the available information on BMP cost-effectiveness and project benefits is included in the project profiles in this publication.

Cost-Effective BMPs

Modeling results from the Idaho, Illinois and Pennsylvania RCWP projects suggest that, for a given government expenditure, greater reductions in sediment delivery to water bodies may be achieved by widespread implementation of conservation tillage instead of more limited implementation of structural practices. This suggests that some water quality benefits are not well served by traditional conservation programs that spend large amounts of money controlling erosion on few acres. Such programs are changing, promoting conservation tillage and other conservation practices under long-term agreements and contracts.

Practices that are cost-effective in one area may be ineffective in others. For example, long-term animal waste storage systems in the Vermont RCWP help control nutrient runoff by permitting more timely manure application that meets crop needs and avoids periods of high runoff from rainfall. In contrast, the same practice in the Pennsylvania project results in higher nutrient delivery to ground and surface waters. This is because the high animal population in the Pennsylvania project produces a very large quantity of manure that far exceeds crop

1 Economic analysis is based on contributions from the USDA Economic Research Service.

nutrient needs when the manure is spread on project area cropland. Long-term manure storage preserves nutrients that would have been lost by volatilization and overloads spreading areas in a few, infrequent pulses. Also, because the practice increases efficiency of operations, the farmer might be inclined to increase animal numbers and further worsen the excess nutrient problem. Reducing animal numbers, installing short-term storage systems that increase volatilization of nitrogen, and transporting manure out of the watershed appear to be the preferred approaches.

In the Idaho project, the use of conservation tillage and irrigation water management appears to be more cost-effective for reducing sediment yield than the expensive structural irrigation improvements (concrete ditches, gated pipe, etc.), sediment basins, and temporary retention devices previously promoted. Also, the management practices require no periodic cleaning or other out-of-pocket expenses and are, therefore, likely to be continued after the end of the contract period. Conservation management is preferred, too, because it provides long-term crop yield benefits by leaving soil in place on the field, rather than just keeping it out of the stream.

Modeling results from the SD-RCWP indicate that split application and injection of fertilizer would be very cost effective BMPs in reducing nutrient loadings to local lakes.

Incentives To Participate

Practices that reduce pollutant levels have to be adopted by high proportions of the farmers in critical areas if lasting impacts on water quality are to be achieved. In most RCWP projects government cost-sharing up to 75 percent of BMP installation cost and free technical assistance have been sufficient incentives to achieve farmer participation in the voluntary program.

But will farmers continue the practices without cost share incentives after the contracts expire? Economic analysis indicates that those practices that will continue include improved management practices such as conservation tillage, pesticide and fertilizer management, and irrigation water management, all of which tend to reduce production costs. Conservation tillage may also increase short- and long-term yields when the farmer becomes experienced in its application, providing a further incentive to continue the practice. Fertilizer management involving split application and injection may save sufficient nutrients to permit lower application rates and fertilizer purchases to offset slightly increased costs of application. BMPs that will likely be discontinued include temporary structural practices such as sediment retention basins and devices that require non-cost-shared expenditures for maintenance. Some terraces may also cease to be maintained. However, with implementation of the conservation compliance provisions of the Food Security Act of 1985, farmers may be less likely to abandon soil and water conservation practices already in place.

In the Pennsylvania project, a program of technical assistance and an I & E program without contracts has been developed to promote water quality practices. I & E efforts point out to project area farmers that over-application of nutrients relative to crop needs can contaminate the farmers' own sources of groundwater. Technical assistance stresses improving fertilizer and manure management by soil testing to match nutrient application with crop needs and by replacing commercial fertilizer with animal waste. Although these efforts have improved participation in the RCWP, it is still much lower than needed to generate significant water quality improvements.

Economic Benefits Versus Costs in Project Selection

Water quality change alone is insufficient to measure economic damage or potential economic benefits for selection of NPS control projects. Other important elements are the type and extent of water use impairment, the number of people affected, and the extent to which water quality may improve with NPS control. Even though a project improves water quality, representing success from a physical impacts point of view, if use of the water changes little and few people benefit, the project may not be successful from an economic and social perspective.

The Vermont project has most of the elements needed for a cost-effective NPS project. Nutrient pollution from animal waste and sewage treatment has impaired swimming, fishing, and other recreation on St. Albans Bay and lowered the value of recreational property. Substantial improvement in water quality from point and nonpoint source pollution control is expected to restore beneficial uses for many people. Even though the project is costly, benefits substantially exceed the costs largely because the impaired water uses are extensive and of high value to the public.

Like the Vermont project, the South Dakota project also addresses nutrient pollution in heavily used recreational lakes with high public value. Land treatment costs are low because inexpensive management BMPs are used. Economic benefits from water quality improvements could easily exceed project costs, but the project has not demonstrated a sufficiently comprehensive effort to achieve significant water quality improvement.

In the Illinois project, there is little economic damage attributable to the high turbidity and sediment from agricultural runoff. Because Highland Silver Lake is a domestic water supply where recreational use is restricted, improved water quality would benefit few. Protecting storage capacity also has little economic value because the sedimentation rate is low relative to capacity and has little effect on water treatment costs. Improved water quality would thus produce only modest economic benefits that would not offset project costs.

The Idaho RCWP is reducing sediment in irrigation return flows to improve fishing in Rock Creek and reduce sediment loadings to the Snake River. Economic benefits from recreational fishing in Rock Creek are modest because few people benefit directly. Reduced sediment loading to the Snake River produces few economic benefits because the Snake River is a large resource in which other sources and channel erosion overshadow the impact of reduced sediment loadings in Rock Creek on storage and power generation downstream from the project area. Water quality economic benefits would have exceeded government costs, however, if low cost management BMPs (e.g., conservation tillage) had been promoted instead of expensive irrigation structures.

The economic evaluation of RCWP outlined above focuses on economic benefits that are readily quantified, such as recreation, drinking water, and commercial fishing, largely because these data are available from existing sources that pre-date RCWP. Two additional types of benefits, ecological and experimental, are also very important in RCWP even though they resist quantification. Experimental benefits, in particular, may not be recognized until the lessons for RCWP are applied to NPS management programs throughout the nation.

CONCLUSION

After several years of recognizing NPS control as central to achieving the goals of the 1972 Clean Water Act, there is finally a public policy to implement NPS control nationwide. With the Water Quality Act of 1987 comes new responsibility for action at the state level. States are now in the process of developing management plans under section 319 to address their particular NPS problems. RCWP experiences and results should figure prominently in these plans.

It has been recognized in previous programs, such as the Model Implementation Program, that documenting water quality improvements on a watershed basis may take a long time because of large variations in hydrologic and meteorologic conditions from year to year. While many of the RCWP projects have yet to document water quality changes, and some may never do this, the findings and experiences to date of RCWP are important guidelines for NPS management. From an overall perspective, the RCWP experiment is providing many pieces of information that will help to address broad questions about NPS control with well documented evidence. This valuable information is available now to meet the challenge of NPS control under Section 319. However, the RCWP experiment is only half over and, thus, not all the results are in. We have much to learn yet from RCWP.

REFERENCES

Carter, D.L., Personal communication, October 6, 1987.

Dressing, S.A., R.P. Maas, M.D. Smolen, and F.J. Humenik, 1984. Proceedings of the Rural Clean Water Program C, M, & E Workshop. April 2-5, 1984, Raleigh, NC. North Carolina Agricultural Extension Service, Raleigh, NC.

Garvin Brook RCWP, 1986 Annual Progress Report, p. 12.

Maas, R.P., M.D. Smolen, C.A. Jamieson, and A.C. Weinberg, 1987. Setting Priorities: The Key to Nonpoint Source Control. USEPA Office of Water, Regulations and Standards Division, Washington, DC.

Magleby, R.S., Personal communication, September 3, 1987.

Spooner, J., R.P. Maas, M.D. Smolen, and C.A. Jamieson, 1987. Increasing The Sensitivity of Nonpoint Source Control Monitoring Programs. In: Proceedings of the Symposium on Monitoring, Modeling, and Mediating Water Quality. American Water Resources Association, pp. 243-257.

Spooner, J., C.A. Jamieson, R.P. Maas, and M.D. Smolen, 1987. Determining Statistically Significant Changes in Water Pollutant Concentrations. J. Lake and Reservoir Management, 3:195-202.

Chapter Two — Project Profiles

Profiles of Nonpoint Source Projects

This chapter contains profiles of all active RCWP projects (20) and three other NPS control projects. The profiles provide brief sketches of each project in outline form, including major contributions to NPS control, specific results and lessons learned. A listing of project documents and personnel contacts also are included.

Information on cost of BMPs, changes in water resource use, and potential economic benefits was contributed by Richard Magleby, C. Edwin Young, and Steven Piper of the USDA Economic Research Service.

LAKE THOLOCCO - RCWP 1

Dale and Coffee Counties, Alabama
MLRA: P-133A
H.U.C. 031402-01

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

Voluntary farmer participation is possible even in an economically depressed agricultural area if practices are acceptable and there is enthusiastic one-on-one contact by local agricultural agency representatives. Preliminary water quality results indicate that fecal coliform concentrations can be reduced significantly by treating a few key animal operations.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980-1991

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): $1,831,048

4. **Cost Share Budget:**
   a. Funds Allocated: $1,409,448
   b. Total Farmers' Contributions: $276,132 as of Sept. 30, 1986

5. **Water Quality Monitoring Budget:** $163,187

6. **Watershed Area:** 51,400 acres

7. **Project Area:** 51,400 acres

8. **Critical Area:** 9,270 acres

9. **Project Land Use:** (equivalent to watershed land use)

Land Use	% project area
cropland	15
pasture/range	7
woodland	55
urban/roads	4
other	19

10. **Animal Operations in Project Area:**
    a. Dairy: none reported
    b. Beef: none reported
    c. Swine: 20 farms with average of 200 pigs/hogs (800 a. u.)
    d. Poultry: none reported

11. **Water Resource Type:** streams, Lake Tholocco (impoundment)

12. **Water Uses and Impairments:**
    Lake Tholocco was built primarily for swimming and water-skiing, and it's designated use is swimming, fishing and wildlife. Watershed streams have a fish and wildlife classification. The lake is used for

recreation by over 100,000 people each year. Boating and fishing account for about 20,000 user-days per year.

a. The lake was closed to body contact recreation for 85 days during 1979 due to high bacteria levels.
b. The lake has not been closed to contact recreation since then.
c. Capacity of the lake is impaired by sediment, affecting boating and water-skiing.

13. Water Quality at Start of Project:
Fecal coliform densities often exceeded 200/100ml in Lake Tholocco and 5000/100ml in tributaries.

14. Meteorologic and Hydrologic Factors:
a. Mean Annual Precipitation: 55 inches
b. USLE 'R' Factor: 400
c. Geologic Factors: The project area is located in the Lower Coastal Plain. Soils range from loamy sands to fine sandy loams. Topography is rolling to steep.

15. Water Quality Monitoring Program:
a. Timeframe: 1980-1990
b. Sampling Scheme:
1. Location and number of monitoring stations: 7 lake stations and 9 tributary stations
2. Sampling Frequency: biweekly summer, monthly other times
3. Sample Type: grab
c. Pollutants Analyzed: suspended solids, turbidity, fecal coliform, total coliform, nitrate
d. Flow Measurements: began in 1983

16. Critical Areas:
a. Criteria: erosion rate, distance to watercourse, present cropping practices, present manure management practices
b. Application of Criteria: The project has generally adhered to its critical area criteria in committing cost share funds.

17. Best Management Practices:
a. General Scheme: Treat nearly all cropland; fix gullies; treat swine operations near streams
b. Quantified Implementation Goals: 6,953 acres, 8 swine operations
c. Quantified Contracting/Implementation Achievements:

location	% under contract	% implemented
project area	14.5	11.6
critical area	80	64
critical area farms	82.6	66
project area farms	18.6	15

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	69/ac.	128/ac.	197/ac.
2 animal waste mgmt.	675 ea.	12,800 ea.	13,475 ea.
4 terraces	44/ac.	176/ac.	220/ac.
5 diversions	20/ac.	79/ac.	99/ac.
6 grazing land prot.	1,630 ea.	4,900 ea.	6,530 ea.
7 waterways	215/ac.	870/ac.	1,085/ac.
8 cropland prot.	56/ac.	84/ac.	140/ac.
9 conservation tillage	33/ac.	97/ac.	130/ac.
10 stream prot.	22/ac.	90/ac.	112/ac.
11 perm. veg. cover	80/ac.	450/ac.	530/ac.

(continued on next page)

12 sediment retention, erosion control struc.	440 ea.	3,960 ea.	4,400 ea.
14 tree planting	11/ac.	33/ac.	44/ac.
16 pesticide mgmt.	2/ac.	6/ac.	8/ac.

e. Effectiveness of BMPs: Sediment control BMPs have reduced soil loss by 2.3 tons/acre on the 7,430 acres treated.

18. Water Quality Changes: Maximum fecal coliform concentration observed in Lake Tholocco has not exceeded 200/100ml since 1982.

19. Changes in Water Resource Use:
There is no documented change in water resource use since RCWP began. There have been no lake closures since 1980 due to high bacteria levels and lake use has remained steady at approximately 100,000 user-days per year. Reduced sedimentation is thought to have protected boating and fishing areas from degradation.

20. Incentives:
a. Cost Share Rates: 75% for most practices
b. $ Limitations: $50,000
c. Assistance Programs: none

21. Potential Economic Benefits:
a. On-farm: not evaluated
b. Off-farm:
1) Recreation: $65,000 - $195,000 per year
2) Water Supply: 0 - $5,000 per year
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: 0

III. Lessons Learned

This is an extremely depressed farming area with an average net farm income of only $6,400 in 1974. The success of the project in obtaining farmer participation shows that aggressive marketing by the local agricultural agency personnel combined with water quality plans that integrate on-farm concerns can work even under very economically depressed conditions.

IV. Project Documents

1. "Lake Tholocco Rural Clean Water Project. Application Dale and Coffee Counties, Alabama". July 15, 1979. Alabama Rural Clean Water Coordinating Committee.

2. "Water Quality Monitoring Report Lake Tholocco RCWP Project, Fiscal Year 1981". November 1981. Alabama Water Improvement Commission.

3. "1982 Annual Progress Report, Lake Tholocco". 1982. Rural Clean Water Program.

4. "Water Quality Monitoring Report Lake Tholocco RCWP Project, Fiscal Year 1982". November 1982. Alabama Department of Environmental Management.

5. "1983 Annual Progress Report, Lake Tholocco". 1983. Rural Clean Water Program.

6. "Water Quality Monitoring Report Lake Tholocco RCWP Project, Fiscal Year 1984". October 1984. Alabama Department of Environmental Management.

7. 1984 Annual Progress Report, Lake Tholocco". 1984. Rural Clean Water Program.

8. "1985 Annual Progress Report, Lake Tholocco". 1985. Rural Clean Water Program.

9. "1986 Annual Progress Report, Lake Tholocco". 1986. Rural Clean Water Program.

V. NWQEP Project Contact

Water Quality Monitoring
Mr. Victor Payne
USDA - Soil Conservation Service
P.O. Box 311
Auburn, AL 36830
tel. (205) 821-8070

Land Treatment/Technical Assistance
Mr. Bennie Moore
USDA - SCS
984C E. Andrews Ave.
Ozark, AL 36360
tel. (205) 774-4749

APPOQUINIMINK RIVER - RCWP 2

New Castle County, Delaware
MLRA: 149A
H.U.C. 020402-05

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

This project shows a declining trend in P concentration, attributable to BMPs. This appears to be due to a high level of BMP implementation early in the project timeframe and a consistent water quality monitoring effort at a stream station within the project area. The project has also shown that farmers are willing to make adjustments in their practices to help improve water quality.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980-1991

3. **Total Project Budget:** $977,027 (ref. 7)

4. **Cost Share Budget:**
   a. Funds Allocated: $866,045
   b. Farmer' Contributions: $426,109 as of 1991 (estimated, ref. 7)

5. **Water Quality Monitoring Budget:** $114,000

6. **Watershed Area:** 30,762 acres

7. **Project Area:** 30,762 acres

8. **Critical Area:** 13,000 acres

9. **Project Land Use:**

Use	% Project Area
cropland	63.7
pasture/range	4.1
woodland/wetlands	27.8
urban/roads	4.4

There are about 160 farms in the project area, mostly grain and vegetable producers. Eighty-five percent of these farms are located in the critical area.

10. **Animal Operations in Project Area:**
    a. Dairy: 6 farms with average of 105 cows (635 a. u.)
    b. Beef: 2 farms with average of 147 cattle (249 a. u.)
    c. Swine: 1 farm with unknown number of animals
    d. Poultry: 1 with 70,000 layers (350 a. u.)

Most dairy, beef and hog operations are along or near streams. None had animal waste treatment facilities before the RCWP.

11. Water Resource Type: lakes, streams, Appoquinimink River

12. Water Uses and Impairments:

The lakes and streams of the Appoquinimink River watershed are used for recreation by approximately .5 million people who live within 20 miles of the watershed. Water uses include passive recreation (sightseeing and birdwatching) and active recreation (fishing, hunting and boating). Contact recreational uses such as swimming have been constrained by degraded water quality at Silver Lake in recent years. Appoquinimink River water quality is fair. All lakes have eutrophic conditions with dense aquatic vegetation and algal growth due to excessive nutrient concentrations.

13. Water Quality at Start of Project: (ref. 4)

The Appoquinimink River had high nutrient levels. All three impoundments were eutrophic.

Water Quality Characterization for the Appoquinimink River (1977)

Pollutant	Wiggins Mill Rt. 446	Silver Lake Pond	Noxontown Pond
	mg/l		
Total IN	1.1	4.6	1.0
TKN	2.3	5.4	2.0
TP	0.4	0.2	0.2
Chl a	—	27.0	38.0

Fecal coliform standards (200/100ml) were typically violated throughout the watershed during ambient conditions, even though point sources do not indicate violations of fecal coliform standards.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 45 inches

b. USLE 'R' Factor: 200

c. Geologic Factors: The watershed is underlain by deep sediments covering the bedrock. The surface formation consists largely of medium to coarse sands and gravels. This formation is an important water supply presently used as a potable water source for public and private supplies. The predominant soil type is deep, well-drained and medium to coarse textured. Slopes are nearly level in the uplands and steep near the stream channels.

15. Water Quality Monitoring Program:

a. Timeframe: Monitoring began in 1980 at Wiggins Mill, in 1983 at Silver Lake and Noxontown Pond. Groundwater monitoring began in 1984. Monitoring at the river and pond stations ended in 1986. Groundwater monitoring ended in July 1987.

b. Sampling Scheme:

1. Location and Number of Monitoring Stations:
    a) Wiggins Mill Pond - one station to monitor a 2,200-acre subwatershed of the project areas
    b) Noxontown Pond, Silver Lake and Shallcross Lake - 3 stations for each waterbody (2 within the lake and 1 at the outlet)
    c) Groundwater - 2 row crop sites, 2 potato field sites
2. Sampling Frequency:
    a) monthly for baseline data development of all physical/chemical parameters and generally bimonthly for biological indicators
    b) three storm event samples collected seasonally
    c) periodic water quality surveys taken at Silver and Shallcross Lakes
3. Sample Type: grab

c. Pollutants Analyzed: filtered and unfiltered N and P series, chl *a*, suspended and dissolved solids, COD, DO, FC, FS, BOD.

d. Flow Measurements: taken with each sample at Wiggins Mill

e. Other: temperature, alkalinity, acidity, pH also measured

16. Critical Areas:

a. Criteria: - soil erosion exceeds T value
  – gully erosion (including ephemeral) is present
  – concentration of animal wastes are 1,500 feet or less from a stream
  – need for better farm management with respect to application of fertilizer, pesticides and animal wastes

b. Application of Criteria: Critical area designation for individual contracts was determined by soil conservationists using the above criteria on a field by field basis.

17. Best Management Practices:

a. General Scheme: Primary BMPs are conservation tillage, fertilizer management and pesticide management. There is some implementation of animal waste management systems, primarily in the areas of manure - holding structures and calibration of manure application equipment.

b. Quantified Implementation Goals: The project goal was to treat 9,750 acres of the 13,000 critical area.

c. Quantified Contracting/Implementation Achievements: as of Sept. 30, 1985. (ref. 13)

Location	% under contract	% implemented
project area	37.0	37.0
project area cropland	85.0	NA
critical area	87.4	87.4
project area farms	48.0	48

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)
1 perm. veg. cover	85/ac.
2 animal waste mgmt.	10,110 ea.
5 diversions	1/ft.
7 waterways	1,550/ac.
8 cropland protection	14/ac.
9 conservation tillage	13/ac.
11 perm. veg. on crit. acres	330/ac.
12 sediment retention, erosion control structures	2,000 ea.

e. Effectiveness of BMPs:

1. Cost shared BMP installation for FY1986 saved 7,233 tons of soil on 977 acres (7 tons of soil per acre).

2. Improved fertilizer and pesticide management (BMPs 15 & 16) has reduced the rate of P application on cropland to one-half the amount needed if P were broadcast applied. Split N application for corn has minimized the opportunity for large amounts of N to wash away soon after application.

3. Installation of manure holding structures allows the farmer to store animal waste for timely application to meet crop needs.

4. Meetings and printed fact sheets on how to calibrate fertilizer and pesticide application equipment are expected to improve the calculation of correct amounts and rates for application.

5. Changing tillage practices and implementation of BMPs which disturb less acreage has resulted in a decrease of more than 60 percent in the concentrations of suspended solids and total P reaching the stream. The BMPs credited with this effect include the following practices: permanent vegetative cover, waterway, cropland protection system, conservation tillage system, permanent vegetative cover for critical area, and erosion/water control structure.

18. Water Quality Changes:

Wiggins Mill data for 1986 show a dramatic, steady decline of 90% in sediment concentrations since 1980. Total phosphorus concentrations have declined by 65-70% since 1980.

NO_3-N concentrations at Wiggins Mill have declined slightly the last two years. Chlorophyll *a* concentrations have increased sharply the last two years in Wiggins Mill and have increased through the sampling history for all three ponds.

19. Changes in Water Resource Use:

There are no documented changes in water use. However, swimming is not currently allowed in Silver Lake due to high bacteria, and algae in Noxontown Pond impairs boating. Assuming the area is used for recreation primarily by local residents and they would recreate at the state average, an additional 18,000 swimming user-days and 42,000 boating user-days could be possible if water quality improves in the future.

20. Incentives:

a. Cost Share Rates: up to 75%
b. Limitation: $50,000
c. Assistance Programs: fertilizer and pesticide management programs conducted by the Extension Service.

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
1) Recreation: $15,000 - $180,000 per year.
2) Water Supply: 0
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: unknown

III. Lessons Learned

The project reports that implementation of BMPs existed prior to RCWP but no records are available that track those accomplishments, thus the pre-project level of implementation is difficult to define. The project feels that this factor combined with the lack of baseline data in the sampling program may preclude demonstrating water quality improvements as a direct result of BMP implementation under RCWP. The sampling program's ability to detect subtle changes in water quality may have been hampered by the timing of RCWP efforts in relation to what had already been accomplished.

IV. Project Documents:

1. U.S. EPA National Eutrophication Survey Working Paper Series: Report on Silver Lake, New Castle County, Delaware. Working Paper No. 240. June 1975.

2. State of Delaware. Water Quality Standards for Streams. Department of Natural Resources and Environmental Control. Amended March 25, 1979.

3. Regional Nutrient Technical Advisory Committee. Recommendations for Reducing Losses of Applied Nutrients in Region III of the EPA. 12/31/79.

4. New Castle Conservation District and the Water Resources Agency for New Castle County. Agricultural Nonpoint Source Control Program for the Appoquinimink River Basin. Rural Clean Water Program Proposal. Revised July 1979.

5. Water Resources Agency for New Castle County. Rural Clean Water Program Monitoring and Evaluation (DRAFT Plan). April 16, 1980.

6. RCWP Appoquinimink Project, New Castle County, Delaware. Monitoring and Evaluation Report. 1981.

7. RCWP Appoquinimink Project. New Castle County Delaware. Plan of Work Update for 1982.

8. Appoquinimink Rural Clean Water Program. Annual Progress Report. 1982.

9. RCWP Appoquinimink Project. New Castle County, Delaware. Annual Report. 1983.

10. Appoquinimink Project. New Castle County, Delaware. RCWP Progress Summary for Fiscal Year 1983. Plan of Work: Update for 1984.

11. RCWP Progress Summary for Fiscal Year 1984.

12. Ritter, W.F. and R.W. Lake. 1984 Summary of Water Quality Monitoring in the Appoquinimink Watershed. Appendix D to RCWP Progress Report.

13. RCWP Progress Summary for Fiscal Year 1985.

14. RCWP Progress Summary for Fiscal Year 1986.

V. NWQEP Project Contacts

Water Quality Monitoring
Bruce Kraeuter
Water Resources Agency
2701 Capitol Trail
County Engineering Building
Newark, Delaware 19711
tel. (302) 731-7670
and
Bill Ritter
College of Agricultural Science
Department of Agricultural Engineering
Townsend Hall
Newark, Delaware 19717-1303
tel. (302) 451-2468

Land Treatment/Technical Assistance
Jack Lakatosh
USDA - SCS
6 Peoples Plaza
Newark, Delaware 19702
tel. (302) 834-3560

ROCK CREEK - RCWP 3

Twin Falls County, Idaho
MLRA: B-11
H.U.C.: 170402-12

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

Information on the effectiveness of BMPs in an irrigated system has been gained from this project. After five years of water quality monitoring, significant sediment concentration reductions have been found in at least five subbasins. Additional documentation of the relationship between land treatment and water quality is expected. Detailed analysis of this project is available in the NWQEP--CM&E Report, 1985.

II. Project's Characteristics and Results

1. Project Type: RCWP, Comprehensive Monitoring and Evaluation Project

2. Timeframe: 1981-1991 for water quality monitoring; BMP implementation will continue until 1996.

3. Total Project Budget: (excludes water quality monitoring and farmers' contributions): $3,422,719

4. Cost Share Budget:
- a. Funds Allocated: $1,954,591
- b. Total Farmers' Contributions: $2,083,246 (estimate as of 1996)

5. Water Quality Monitoring Budget: $1,133,000

6. Watershed Area: 198,400 acres

7. Project Area: 45,238 acres

8. Critical Area: 28,159 acres (includes 46 critical animal operations)

9. Project Land Use: (ref. 35 and 16)

Use	% project area	% watershed area
cropland (irrigated) (includes alfalfa)	74.5	26
pasture/range	NA	55
woodland	NA	13
urban/roads	NA	6

10. Animal Operations in Project Area: (personal communication, Bill Clark, Idaho DOE, Aug. 1986)
- a. 34 dairy farms with average of 200 cows (6,800 a.u.)
- b. 21 beef cattle farms with average of 300 cattle (5,355 a.u.)
- c. 1 mink farm with average of 20,000 mink (~200 a.u.) - not thought to be a critical farm

11. Water Resource Type: Irrigation canals and Rock Creek (approx. 20 miles) flowing into the Snake River

12. Water Uses and Impairments:
Rock Creek provides diverse habitat for wildlife and is a popular stream for swimming, tubing and fishing. Water-skiing and swimming are major recreational activities in the Snake River, 10-15 miles

downstream from the confluence with Rock Creek. Rock Creek receives irrigation return flow from the RCWP project area.

The primary use impairments are to fishing and contact recreation in Rock Creek, and to irrigation ditches, canals and drains which become clogged with sediment. Fishing use of Rock Creek in 1981 was about 500 fishing days compared to an estimated 8,000 if it were a quality trout fishery.

High sediment loads in Rock Creek may have created additional equipment and maintenance costs for filtering sediment and removing gravel at the hydroelectric plant near the confluence of Rock Creek with Snake River (personal communication, Bill Clark, Idaho DOE, 10/13/87). These costs are not formally documented and are subject to debate. The muddy color of Rock Creek is an aesthetic impairment which also effects the Snake River. The primary pollutants are sediment, phosphorus, nitrogen and bacteria coming mostly from irrigation return flow and feedlot runoff. Sediment loads entering the Snake River from Rock Creek do not appear to be significantly impairing downstream reservoir capacity and causing increased cost of power generation. The nearest power plant which relies on reservoir capacity is 120 miles downstream.

13. Water Quality at Start of Project:

1980 flow-weighted mean concentrations at the mouth of Rock Creek: (Monitoring site S-1)

Pollutant	Concentration
TSS	158.0 mg/l (irrigation season only)
TP	0.123 mg/l (irrigation season only)
TN	3.3 mg/l (water year)
FC	1182.0 mpn (geometric mean)

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 8.5 inches

b. USLE 'R' Factor: ~ 20

c. Geologic Factors: The watershed is underlain by limestone, quartzite, shale, sandstone, granite and metamorphosed sediments. This formation yields large supplies of groundwater to the northeast. Soils in the project area are highly erosive. Subsoils range from silty to loamy. Surface soils are generally medium textured. Slopes range from nearly level to very steep on hill and mountain sides.

15. Water Quality Monitoring Program:

a. Timeframe: 1981 - 1991

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: Monitoring stations have been established on Rock Creek since 1980, and at 6 of the 10 project subbasins since 1981. The subbasin stations are located on irrigation ditches. Some of the subbasin stations have been positioned in pairs at inlets from supply canals and at upstream and downstream points to Rock Creek. There are 19 monitoring stations on irrigation ditches and 6 stations on Rock Creek. There was a monitoring station on the Twin Falls Main Canal from 1980 - 1983.
2. Sampling Frequency: Biweekly to weekly at the Rock Creek and and subbasin stations during the irrigation period. Monthly monitoring is performed during the non-irrigation season.
3. Sample Type: grab samples

c. Pollutants Analyzed: TP, OP, TSS. FC, TKN, inorganic-N for the Rock Creek and the subbasin samples. Additional parameters are analyzed on Rock Creek including macroinvertebrates, fish population analysis, pesticides, and metals.

d. Flow Measurements: instantaneous flow taken with each grab sample

16. Critical Areas:

a. Criteria: All the irrigated cropland and animal production facilities are considered critical. The 10 subbasins within the project area were prioritized by project personnel. In addition, NWQEP examined the relative upstream- downstream water quality in subbasins 1,2,4,5, and 7. Subbasins 2 and 7 and the subbasin drained by sampling stations 4-4 and 4-3 have additional potential for sediment reduction. These subbasins and subbasin 5 also have potential for improvement in FC, phosphorus, and nitrogen levels.

b. Application of Criteria: The implementation of BMPs has not followed the order of subbasin priority because of economic conditions and the desire to issue contracts in the order that applications were received.

17. Best Management Practices:

a. General Scheme: Focus during 1981-1984 was on sediment retention structures and irrigation management systems with some permanent vegetative cover on critical areas (RCWP BMPs 12, 13, and 11). Several other practices were approved, but few were implemented (i.e., RCWP BMPs 2, 9, 15, and 16). For the duration of the project, 1985-1991, emphasis has shifted to conservation tillage (BMP 9) and animal waste management (BMP 2).

b. Quantified Implementation Goals: The project goal is to install BMPs on 75 percent of the critical erosion acres within 10 years. The deadline for contracts was September 30, 1986. However, amendments to existing contracts will add conservation tillage beyond that date. It appears the implementation may fall short of the stated goal, especially in animal waste management.

c. Quantified Contracting/Implementation Achievements: as of 9/30/86 (Ref. 38)

Location	% under contract	% implemented
project area	47	NA
critical area	75	5
critical area farms	67	NA
project area farms	67	NA

d. Cost of BMPs: Costs of implementing principal BMPs were estimated in terms of the total change in variable and fixed costs per acre. Least costly were conservation tillage and irrigation water management (IWM), which actually reduced total costs:

BMP	$/Acre change in cost/yr.
9 Conservation tillage	$33 cost savings
13 IWM	$4 cost savings
11 Filter strips	$2 cost savings
12 Sediment retention	$9-15 added cost
13 Irrigation structures	$20-48 added cost

e. Effectiveness of BMPs: With 75% of the critical area under treatment, expected decreases in pollutant loads to Rock Creek from subbasins are estimated at 70 percent sediment, 70 percent TP and 65 percent toxics (mostly pesticides) (ref. 35, p.2). These estimated reductions appear to be feasible based on water quality data analysis already conducted (NWQEP, 1985).

Sediment reduction coefficients for the sediment retention BMPs have been developed by the USDA-ARS at Kimberly, ID. Mini-Basins, I-slots, sediment basins, and buried pipe runoff were effective with coefficients between 75 and 92 percent. Vegetative filter strips have a coefficient of 50 percent, irrigation improvements 5 to 40 percent, and conservation tillage 60 percent.

Management practices are by far the most cost-effective for reducing sediment loss on a per acre basis:

BMP	$Change in cost/acre per one % reduction in sediment/acre
9 Conservation tillage	$0.55 reduced cost
13 IWM	0.11 reduced cost
11 Filter strips	0.04 added cost
12 Sediment retention	0.09-0.17 added cost
13 Irrigation structures	0.48-5.20 added cost

18. Water Quality Changes:

Suspended sediment has decreased significantly in five of six subbasins studied. Severe streambank erosion on the upper reaches of Rock Creek may be masking some of the effect on Rock Creek. Fish sampling shows an increase in native trout populations in Rock Creek since 1981.

Based on a model of the watershed, full implementation of the project as contracted would reduce sediment loadings to Rock Creek by 20 to 31 percent compared with pre-project conditions. Modification of contracts to implement 10,000 acres of conservation tillage is expected to reduce sediment loadings by 52 to 63 percent (ref. ERS, 1987).

19. Changes in Water Resource Use:

A 52-63 percent reduction in sediment loadings should help restore Rock Creek as a quality trout fishery, increasing fishing days per year from 500 prior to the project up to possibly 8,000. Other recreational uses of the Creek and the Snake River would be enhanced, but not so directly or dramatically as the fishery.

20. Incentives:

a. Cost Share Rates: 50 or 75 % depending on the practice
b. $ Limitations: $50,000 maximum on sediment retention and agricultural waste control systems, less for other BMPs
c. Assistance Programs: The University of Idaho has demonstration and research plots for conservation tillage. Researchers at the USDA-ARS station at Kimberly, Idaho have conducted extensive research on conservation tillage as a management practice for southern Idaho. There is a need for better technical assistance for animal waste management. A full-time SCS position for I & E activities was created in 1986 and will continue until the end of the project. The project publishes a newsletter, creates media contacts, and promotes publicity.
d. Other Incentives or Regulations: The General Permit for Confined Animal Feeding Operations in Idaho (EPA Region X) was passed into law in June 1987. Since the deadline for BMP contracts was September 1986, the new law will not have the significant incentive to implement animal waste management that was hoped. Fines for violating the permitting system may, however, speed implementation of animal waste management. Existing contracts can still be modified, to include BMP2.

21. Economic Benefits:

a. On-farm: Farmers are gaining soil productivity (long term yield) maintenance benefits from conservation tillage and irrigation practices which keep soil in place in the fields. Conservation tillage also reduces short term costs. Farmers also get depreciation deductions on income tax for the structural measures installed. Modification of contracts to add additional conservation tillage (CT) could substantially increase on-farm benefits over 50 years:

Benefits:	Project as contracted 9/86 (in million $ present value)	Project with 10,000 acres of CT
Cost share payments received	1.2	1.3
Short & long term yield benefits	1.0	1.9
Tillage cost reduction	0.3	1.2
Tax savings on BMPs	0.9-1.0	0.9-1.0
Gross benefits	3.4-3.5	5.3-5.4
Less Cost of Benefits	2.8-3.1	2.8-3.1
Net on-farm benefits	0.6-0.4	2.5-2.3

b. Off-farm: Estimated benefits over 50 years are:

Benefits:	Project as contracted 9/86 (in million $ present value)	Project with 10,000 acres of CT
Improved water recreation	0.3-0.5	0.8-1.0
Water supply and treatment	N/A	N/A
Commercial fishing	N/A	N/A
Improved hunting (habitat benefit of CT)	negligible	0.2
Reduced ditch cleaning costs	0.1	0.3
Aesthetic benefits	not measured	not measured
Reduced power generation costs	negligible	negligible
Total Off-Farm	0.4-0.6	1.3-1.5

c. Benefits versus Costs: (over 50 years)

	Project as contracted 9/86	Project with 10,000 acres of CT
Benefits:	(in million $ present value)	
On-farm benefits total	0.6-0.4	2.5-2.3
Off-farm benefits total	0.4-0.6	1.3-1.5
Total benefits	1.0	3.8
Costs:		
Government Costs	1.9	2.1
Total benefits minus cost	−0.9	1.7

III. Lessons Learned:

Based on results from this project, irrigation canals appear to respond faster to land treatment than do streams and non-irrigated, humid areas. This is probably due to a relatively low variability in the hydrologic factors associated with the irrigated system, and to greater control of the water resource. Further comparisons with other projects will help to test this hypothesis. Although analyses showed less variability existed in the water quality and flow data of this project compared to projects in humid regions, a 40-60 percent decrease in mean concentrations over a period of 4 to 5 years is still necessary to have a statistically significant change in the water quality of irrigation canals. Data variability is likely to be greater in the Rock Creek and Snake River systems which are more strongly influenced by meteorologic factors. Adjusting for sources of variability (i.e., upstream concentration) has allowed more efficient monitoring to document the water quality changes. Water quality monitoring was used successfully to quantify sediment loads to the impaired resource from subbasins and to indicate the subbasins that could most benefit from BMPs.

Results from the nearby LQ Drain project show that significant reductions in sediment loads may be lost if sediment retention devices are not properly maintained. It is possible that a similar situation could develop in The Rock Creek RCWP. Conservation tillage techniques to reduce in-field erosion are receiving increased emphasis as an effective, low-cost alternative to structural practices for improving water quality; however, the CT adoption rate, is still very low after three years of cost share availability. Many farmers reject CT because it is a non-traditional farming method. Custom operators who farm rented land do not have an economic incentive to practice CT. Most of the crops grown in the project area are dry beans (garden and commercial seed varieties) and sugar beets. Contractors for dry beans know that conventional tillage methods yield good bean crops and they are prone to contract with farmers who practice conventional methods. While there are several surface applied herbicides registered for use on soybeans, there are no such products registered for dry beans. This is a deterrent to adopting CT. (personal communication with Dr. David Carter, USDA-ARS, Kimberly, Idaho, Oct. 6, 1987).

Off-farm economic benefits from water quality improvement in Rock Creek are limited because no large scale recreational or municipal uses are impaired. Even though off-farm benefits may be small, additional implementation of conservation tillage could result in total benefits of the project exceeding costs, and would certainly have done so if the practice could have been implemented earlier in place of the less cost-effective irrigation structures.

IV. Project Documents:

1. Clark, W.H. May 1960. Report on Pollution in Rock Creek: Cassia and Twin Falls Counties, Idaho 1959. Idaho Department of Health, Engineering and Sanitation Section. 30 p.

2. Clark, W.H. February 1973. Report on Effects of Waste Discharges on Water Quality of the Snake River and Rock Creek Twin Falls Area, Idaho. USEPA, Office of Enforcement, National Field Investigations Center, Denver Colorado. 25 p.

3. Itami, B., W. Johnson, J. Miller, G. Hage, J. Sering, J. Atkins, J. Bede, T. Iverson, J.J. Kuska, W.H. Snyder, R.Wells. May 1974. Rock Creek Recreational Resource Inventory and Analysis. 3 p.

4. Clark, W.H. 1975. Water Quality Status Report Rock Creek, Twin Falls County, Idaho 1970-1974. Division of Environment, Idaho Dept. of Health and Welfare, Boise, Idaho. 69 p.

5. Bauer, S.B. April 1979. Water Quality Status Report: Upper Rock Creek (Twin Falls and Cassia Counties). Department of Health and Welfare, Division of Environment, Boise, Idaho. 9 p.

6. Idaho Soil Conservation Commission. April 1979. Idaho Agricultural Pollution Abatement Plan. 79 p.

7. Application for Rural Clean Water Program Funds: Rock Creek, Twin Falls County, Idaho. July 1979. Submitted by John V. Evans, Governor of Idaho. Prepared by Idaho Department of Health and Welfare, Division of Environment. 53 p.

8. Plan of Work: Rock Creek Rural Clean Water Project, Twin Falls County, Idaho. July 1980.

9. Idaho Dept. of Health and Welfare. Idaho Water Quality Status Report 1980. April 1981. Division of Environment (DOE), Bureau of Water Quality. 40 p.

10. Rural Clean Water Project Monitoring Plan, Rock Creek, Twin Falls County, Idaho. December 1980. Soil Conservation Service, Economic Statistical Service, Idaho Dept. of Health and Welfare: DOE, and Science Education Administration. 30 p.

11. Annual Report: Rock Creek RCWP Intensive Monitoring. 1981.

12. Intensive Monitoring Work Plan: Rock Creek Rural Clean Water Project. July, 1981.

13. Brockway, C.E., F.J. Watts, and C.W. Robison. November 1981. Annual Report: Development of a Sediment Generation and Routing Model for Irrigation Return Flow, Rock Creek Intensive Monitoring Program. University of Idaho: Dept. of Agricultural Engineering and Dept. of Civil Engineering, and Idaho Water and Energy Resources Research Institute, Kimberly Idaho. 10 p.

14. Socioeconomic Monitoring and Evaluation Progress Report for FY 1981, Rock Creek RCWP Project - Idaho. January 1982.

15. Rock Creek Rural Clean Water Project Annual Progress Report. October 1, 1982. 12 p.

16. Description of Project Area. 1982. 11 p.

17. Executive Report - Annual Report 1982: Comprehensive Monitoring and Evaluation of Rock Creek RCWP. November 1982. 5 p.

18. Martin, D.M. and S. Bauer. September 1982. Water Quality Monitoring Assessment of the Rural Clean Water Program: First Year Baseline Report, Rock Creek, Water Year 1981. Idaho Dept. of Health and Welfare, DOE, Boise Idaho. 51 p.

19. Carter, D.L. and R.D. Berg. 1982. Rock Creek Intensive Monitoring Project: ARS Activities Report for 1982.

20. Brockway, C.E., F.J. Watts, C.E. Robison, R.P. Sterling. November, 1982. Annual Report: Development of a Sediment Generation and Routing Model for Irrigation Return Flow. University of Idaho: Dept. of Agricultural Engineering and Dept. of Civil Engineering, and Idaho Water and Energy Resources Research Institute, Kimberly Idaho. 54 p.

21. Everts, C. November 1982. Rock Creek Rural Clean Water Project Report on Information and Education Activities. University of Idaho. 6 p.

22. Walker, D.J., J. Hamilton, and P. Patterson. September, 1982. Annual Report Fiscal Year 1982: Economic Evaluation of the Rock Creek Idaho RCWP.

23. Rock Creek Rural Clean Water Project Annual Progress Report: Executive Summary. October 1, 1983. USDA and SCS. Boise Idaho. 21 p.

24. Martin, D.M. 1983. Rock Creek Rural Clean Water Program Comprehensive Monitoring and Evaluation Annual Report. (Attachment I of 1983 Annual Progress Report). Idaho Dept. of Health and Welfare, DOE, Boise, Idaho 83720. 85 p.

25. Carter, D.L. 1983. Rock Creek Rural Clean Water Project Intensive Monitoring Project: Report of ARS Activities for 1983. Attachment II of the 1983 Annual Progress Report. 4 p.

26. Brockway, C.E., F.J. Watts, C.W. Robison, R.P. Sterling, V.L. Watkins. October 1983. Development of a Sediment Generation and Routing Model For Irrigation Return Flow. Attachment III of the 1983 Annual Progress Report. University of Idaho: Dept. of Agricultural Engineering and Dept. of Civil Engineering and Idaho Water and Energy Resources Research Institute, Kimberly Idaho. 44 p.

27. Brockway, C.E., F.J. Watts, C.W. Robison, R.P. Sterling, V.L. Watkins. October 1983. Development of a Sediment Generation and Routing Model For Irrigation Return Flow. Attachment IV of the 1983 Annual Progress Report. Appendix I to attachment III. LQ Drain, An Experiment in Irrigation Return Flow Water Quality Improvement. Attachment IV of the 1983 Annual Progress Report. University of Idaho: Dept. of Agricultural Engineering and Dept. of Civil Engineering, and Idaho Water and Energy Resources Research Institute, Kimberly Idaho, 69 p.

28. Gum, R.L. October 1983. Annual Report: Socioeconomic Evaluation of Rock Creek RCWP. Attachment V of the 1983 Annual Progress Report. Economic Research Service. 5 p.

29. Hamilton, J., P. Patterson, D.J. Walker. September 1983. Economic Evaluation of the Rock Creek Idaho RCWP project. Attachment VI of the 1983 Annual Progress Report. Dept. of Agricultural Economics, University of Idaho. 46 p.

30. Martin, D.M. 1983. Rock Creek Rural Clean Water Program - Idaho. ASAE paper No. 83-2449.

31. Gum R.L. October 1982. Annual Report: Socioeconomic Evaluation of Rock Creek RCWP. Economic Research Service.

32. Rock Creek Rural Clean Water Program Annual Progress Report: Executive Summary. 1984. 33 p.

33. Martin, D.M. 1984. Rock Creek Rural Clean Water Program Comprehensive Monitoring and Evaluation Annual Report. Idaho Dept. of Health and Welfare, DOE, Boise, Idaho 83720. 151 p.

34. Rock Creek Rural Clean Water Program Annual Progress Report: Executive Summary. 1985. 32 p.

35. Clark, W.H. 1985. Rock Creek Rural Clean Water Program Comprehensive Monitoring and Evaluation Annual Report. Idaho Dept. of Health and Welfare, DOE, Boise, Idaho 83720. 153 p.

36. Kasal, J. and R. Magleby. 1985. Economic Evaluation Progress Report for FY85, Rock Creek, Idaho RCWP Project. Economic Research Service, USDA. 29 p.

37. Bauer, S.B. 1985. Pilot Study of Quality Assurance Sample Procedures for Division of Environment Water Quality Surveys. Idaho Dept. of Health and Welfare, DOE, Boise, Idaho. 16 p.

38. USDA, M.J. Neubeiser, W.H. Clark, D.L. Carter, R. Magleby, and ASCS, 1987. Rock Creek Rural Clean Water Program 1986 Annual Progress Report. 31pp.

39. Clark, W.H. 1986. Rock Creek Rural Clean Water Program: Comprehensive Water Quality Monitoring Report, 1981-1986. Idaho Dept. of Health and Welfare, Division of Environment, Boise, Idaho. 147pp.

40. Kasal, J., R. Magleby, D. Walker, and R. Gum, 1987. Economic Evaluation of the Rock Creek, Idaho, Rural Clean Water Project. Economic Research Service, USDA.

41. Gum, R. and Garifo. Recreation Impacts of Improved Water Quality In Rock Creek. Unpublished background paper. Economic Research Service/RTD, USDA. 1984. 5p.

42. Kelly, S. and R. Gum. Income Distribution and the Rural Clean Water Project. Unpublished background paper. Economic Research Service/RTD, USDA. 1984. 9p.

43. LaPlant, D.D., Martin, L. Wear, and R. Gum. Wildlife Habitat Impacts. Unpublished background paper. Economic Research Service/RTD, USDA. 1984. 21p.

44. Walker, D. P. Paterson, J. Hamilton. Costs and Benefits to Improving Irrigation Return Flow Water Quality in Rock Creek, Idaho, Rural Clean Water Project. Research Bulletin no. 139. Agricultural Research Station, University of Idaho. 1986. 30 p.

V. NWQEP Project Contacts

Water Quality Monitoring
William (Bill) H. Clark
Senior Water Quality Analyst
Project Officer, Rock Creek RCWP
Idaho Division of Environment
Dept. of Health and Welfare
450 West State Street
Boise, Idaho 83720
tel. (208) 334-5860

Land Treatment/Technical Assistance
Rick Yankey
Rock Creek RCWP
Soil Conservation Service
634 Addison Ave. W.
Twin Falls, ID 83301
tel. (208) 733-5380

Information and Education
Gayle Stover
Information and Education Specialist
Rock Creek RCWP
Soil Conservation Service
634 Addison Ave. W.
Twin Falls, ID 83301
tel. (208) 733-5380

Economic Evaluation
Richard Magleby
Economic Research Service/RTD
U.S. Dept. of Agriculture
1301 New York Ave., NW, Rm. 532
Washington, DC 20005-4788
tel. (202) 786-1435

HIGHLAND SILVER LAKE - RCWP 4

Madison County, Illinois
MLRA: M-114
H.U.C. 071402-04

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

It is unlikely that the water quality impairment of Highland Silver Lake will be reversed by RCWP. Field study aspects of the project may help to determine if BMPs can reduce the erosion of fine sediment particles from natric soils. (For more information see the RCWP Status Report on the CM&E Projects, 1985, pp. 65-78.)

II. Project's Characteristics and Results

1. Project Type: RCWP, Comprehensive Monitoring & Evaluation Project

2. Timeframe: 1980-1990

3. Total Project Budget (excludes water quality monitoring funds and farmers' contributions): $2,078,406

4. Cost Share Budget:
a. Funds Allocated: $1,402,372
b. Total Farmers' Contributions: $466,990 (estimated)

5. Water Quality Monitoring Budget: $1,655,757

6. Watershed Area: 30,946 acres (ref. 26, p.6)

7. Project Area: 30,348 acres (ref, 26, p.6)

8. Critical Area: 6,525 acres

9. Project Land Use: (ref. 7, p.4)

Use	% project area
cropland	82
pasture/range	5
woodland	4
other	9

10. Animal Operations in Project Area: (ref.26, p.17)
a. Dairy: 760 a.u.
b. Beef: 944 a.u.
c. Swine: 1178 a.u.
d. Poultry: not reported

11. Water Resource Type: streams and a 600-acre impoundment, Highland Silver Lake

12. Water Uses and Impairments: (ref. 1)
Highland Silver Lake is a public water supply for about 8,500 residents in the county. Several industrial firms located in the City of Highland also use the lake for water supply. Non-contact recreational use of the lake includes boating, fishing, and waterfowl hunting. In 1979, the lake supported an estimated

42,600 angler-days.

Use of the lake is impaired by sediments, nutrients and toxics. High turbidity levels are caused by suspension and resuspension of fine natric soil particles. Lake volume is being lost to sedimentation. Excessive nutrient concentrations contribute to eutrophic conditions. Agricultural chemicals in surface runoff entering the lake are a public health concern.

13. Water Quality at Start of Project: (ref. 9, p. III-43)
Average water quality from Site 1, nearest the water intake at the base of the lake (May 1981 - April 1983).

Parameter	Mean	N
TSS	27.8 mg/l	18
Turbidity	57.4 mg/l	17
Secchi	11.4 inches	17
TP	0.18 mg/l	18
TN	2.0 mg/l	18
Chl a	6.26 ug/l	17

14. Meteorologic and Hydrogeologic Factors:
a. Mean Annual Precipitation: 40.5 inches
b. USLE 'R' Factor: ~200
c. Geologic Factors: Soils in the project area are almost entirely glacial in origin. Topography ranges from nearly level to very gently sloping.

15. Water Quality Monitoring Program:
a. Timeframe:
1) lake - May 1981 to 1990
2) streams - Jan. 1982 to Oct. 1984
3) field sites - spring 1982 to Oct. 1984
*All monitoring discontinued Oct. 1984, except at lake sites.
b. Sampling Scheme: (location, frequency, sample type)
9 lake sites (5 main lake & 4 bay sites) sampled monthly
1 lake outflow site sampled daily (MWF) with automatic sampler
3 stream sites sampled daily (MWF) with automatic samplers
8 field sites sampled during events with automatic samplers
c. Pollutants Analyzed:
Daily (MWF) -- TSS,TVS, Turb., Temp., DO, pH & Conductivity sampled at tributary & spillway sites
Semimonthly -- TSS,TVS,Turb., TP, DP, TKN, NO_3, NO_2, Temp., DO, pH, Conductivity sampled at tributary & spillway
Monthly -- ICAP metals sampled at tributary & spillway / TSS, TVS, Turb., TP, TKN, DP, NO_3, NO_2, NH_3, Temp., DO, pH, Conductivity, Total alkalinity, Chl *a*, ICAP sampled at lake sites
Events -- TSS, TVS, Turbidity, TKN, TP sampled at tributary & field sites
d. Flow measurements:
1) spillway - daily
2) streams - continuous
3) field sites - event
e. Other:
1) precipitation at 3 sites within watershed
2) 3 stream sites biologically sampled twice a year
3) 1 channel and streambed survey
4) 1 lake sedimentation survey

16. Critical Areas:
a. Criteria: (1) crop and pasture lands composed of natric soils with fine particle size and high erodibility and slopes greater than 2%. (2) crop and pasture lands of non-natric soils with slopes greater than 5% with high erodibility and proximity to water course. Feedlots are also prioritized according to the

number of animal units and distance to stream.
b. Application of Criteria: The criteria are followed carefully in selection of areas under contract.

17. Best Management Practices:

a. General Scheme: Project uses practices that increase ground cover, decrease the velocity of surface runoff, and improve the management of livestock waste (i.e., RCWP BMPs 1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 14, and 15).
b. Quantified Implementation Goals: The project has established a goal of implementing 75% of its critical areas, which is equal to 4,894 acres. Implementation goals for each BMP have also been established.
c. Quantified Contracting/Implementation Achievements: (as of 1985) (ref.22, p.20)

Location	% under contract	% implemented
project area	18	11
critical area	82	52
critical area farms	89	57
project area farms	53	34

d. Cost of BMPs:

BMP	Expected Average Life (years)	Ave. Annual Gov't Cost/Acre Treated or Benefited ($)
1 Permanent Veg. Cover	5	24
4 Terraces	10	24
5 Diversions	10	22
7 Grassed Waterways	10	5-6
9 Conservation Tillage	4-20	22-4
11 Critical Area Cover	5	8-9
12 Sediment Retention System	10	24
15 Fertilizer Management	3-10	4-1

(Based on CRES data and $17.60 per hour for technical assistance)

e. Effectiveness of BMPs: BMPs have reduced erosion by approximately 42,000 tons per year (USLE) which corresponds with about 19,700 tons of sediment delivered to the lake.
d. Cost-effectiveness of BMPs: Estimates of project-wide cost-effectiveness based on the AGNPS and LP models for three categories of BMPs are:

BMP	cost of sediment control (delivered to lake) $/ton	cost of P control (in lake) $/lb.	cost of 1% reduction (sed. in lake) $1,000	cost of 1% reduction (N & P in lake) $1,000
Conservation Tillage	14–33	7–17	3–7	4–9
Structural Practices (4,5,7,12)	266	172	59	108
Animal Waste Systems	NA	43	–	70

18. Water Quality Changes:

Gage sites: Multiple linear regression analysis of normalized loading data indicates statistically significant reductions in TSS and TP over time.

Lake sites: No statistically significant improving trends have been documented.

The CREAMS and AGNPS models have been used to identify expected changes. According to the AGNPS model, full implementation of RCWP contracts and the increasing adoption of conservation tillage should reduce sediment yield 33 percent and N and P yield 18 percent by 1991 compared to pre-project conditions. However, the net effectiveness of the RCWP project, taking out the conservation tillage trend, gives only about 12 percent reduction in loading of the three pollutants to the lake.

19. Changes in Water Resource Use:

Changes in use of Highland Silver Lake will likely be negligible. A survey of anglers conducted in 1982 indicated that most would increase trips to the lake by about 12 per year if water appearance (clarity) improved to the point of two-foot visibility. Such an improvement is unlikely as projected by models.

20. Incentives:

a. Cost Share Rates: 75%
b. $ Limitations: $50,000 per landowner
c. Assistance Programs: none reported other than the usual I&E and SCS technical assistance.

21. Economic Benefits:

a. On-farm:

Benefits	Discounted Value Over 50 Years (@ 7-7/8% /Year) millions $
Cost share payment	1.2
Tillage cost savings	1.1
Productivity benefits	negligible
Gross benefits	2.3
Costs	
Installation of BMPs	1.6
Maintenance of BMPs	0.2
Total costs	1.8
Net benefit before taxes	0.5

Productivity benefits over 50 years were analyzed using the SOILEC model. The model indicated that benefits from BMP implementation are offset by a lack of productivity benefits, because most soils in the project area are deep.

b. Off-farm:

Benefits	Discounted Value Over 50 Years (@ 7-7/8% /Year)
Boating	Negligible
Fishing	$24,000
Swimming	Not Applicable
Property values	Negligible
Water treatment cost reduction	$225,000
Reservoir capacity	Negligible
Total	$249,000

Fifty-six percent of the surveyed anglers indicted willingness to pay an additional fee to improve water clarity in the lake and that they would increase their visits per year by over one-half. Boating benefits apart from fishing are negligible because of limitations on boat and motor size. The lakes's capacity is large relative to future water supply needs and sedimentation rate is low. Therefore, reducing the sedimentation rate has negligible benefits.

Several other possible benefits such as increased picnicking and aesthetics, improved upland game habitat and reduced maintenance of roadways were not estimated in this analysis due to lack of reliable data.

III. Lessons Learned

The Highland Silver Lake project had much advance planning. Critical areas were defined and a sound monitoring program was developed. However, BMP implementation levels were low and natric soils that produce turbidity even when erosion rate is low were persistent problems. Therefore, the BMPs selected may not be able to alleviate the lake's water quality problem. Most of the water quality monitoring has been discontinued; this will diminish the project's ability to document potential water quality changes within the watershed. A modeling approach was demonstrated. Although it was too late to be used for selecting critical areas and BMPs in this project, it should be evaluated and considered in the initial phases of other programs.

Conservation tillage and fertilizer management were shown to be the least costly BMPs to implement, assuming the practices will be continued well beyond the contract period. Grassed waterways were also shown to have low average annual costs per acre benefited compared with other structural measures and permanent cover.

Conservation tillage was the most cost-effective method of reducing the delivery of pollutants to the lake. Grass waterways and impoundments and animal waste management systems further reduced the generation of pollutants. However, these practices have a very high cost for their expected pollution reduction.

The modeling and economic evaluation show that the cost effectiveness of the project in achieving water quality could have been improved by promoting more extensive adoption of conservation tillage (reduced tillage or no-till) and certain crop rotations (e.g. soybean-wheat/double crop soybean) on all cropland in the watershed rather than using more costly structural measures to reduce erosion to tolerance levels on fewer acres.

The SOILEC model indicated that no significant long-term on-farm benefits are likely from BMPs primarily because of the deep soil over most of the project area.

IV. Project Documents

1. Madison County Soil and Water Conservation District, 1979. Highland Silver Lake: Application for Rural Clean Water Program. Madison County, Illinois.

2. Madison County Local Coordinating Committee, 1980. Plan of Work: Highland Silver Lake RCWP. Madison County, Illinois.

3. Illinois State Coordinating Committee, 1981. Comprehensive Monitoring and Evaluation Program for the Highland Silver Lake Watershed RCWP, Springfield, IL, 40 pp.

4. Illinois State Coordinating Committee, 1981. RCWP Comprehensive Monitoring and Evaluation Report on Highland Silver Lake Watershed. Springfield, IL, 63pp.

5. Makowski, P. and M.T. Lee, 1982. Highland Silver Land Silver Lake Reservoir Yield Analysis. State Water Survey Division, Champaign, IL, 5 pp.

6. Davenport, T.E., 1982. Soil Erosion and Sediment Delivery in the Highland Silver Lake Watershed. Preliminary Analysis. Illinois EPA, Springfield, IL, 35 pp.

7. Illinois State Coordinating Committee, 1982. Highland Silver Lake RCWP CM&E: Annual Report Fiscal Year 1982. Springfield, IL.

8. Davenport, T.E. and M. H. Kelly, 1982. Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project: Phase I. Illinois EPA, Springfield, IL, 121 pp.

9. Illinois State Coordinating Committee, 1983. Highland Silver Lake RCWP CM&E: Annual Report Fiscal Year 1983. Springfield, IL.

10. Davenport, T.E. and Kelly, M.H., 1983. Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project: Phase II. Illinois EPA, Springfield, IL, 145 pp.

11. Eleveld, B., 1983. Baseline On-Site/On-Farm Conditions for the Highland Silver Lake Watershed, Madison and Bond Counties, Illinois (Revised) Agricultural Economics Department, University of Illinois; Champaign-Urbana, IL.

12. Eleveld, B., 1983. Farm Enterprise Budgets for Cropping Activities in the Highland Silver Lake Rural Clean Water Program. Agricultural Economics Department, University of Illinois; Champaign-Urbana, IL.

13. Eleveld, B., 1983. Soil Productivity-Soil Erosion Relationships for Selected Soils Affected by the Highland Silver Lake Rural Clean Water Program. Agricultural Economics Department, University of Illinois; Champaign-Urbana, IL.

14. Eleveld, B., 1983. A Summary of Highland Silver Lake Rural Clean Water Program Cooperators' Conservation Farm Plans. Agricultural Economics Department, University of Illinois; Champaign-Urbana, IL.

15. Southwestern Illinois Metropolitan and Regional Planning Commission, 1983. Highland Silver Lake Comprehensive Monitoring and Evaluation Project: Assessment of Off-Site Socio-Economic Impacts. SIMAPC; Collinsville, IL.

16. Thomerson, J.E. and S.B. Reid, 1984. An Evaluation of the Fisheries of Highland Silver Lake, Madison County, Illinois. Southern Illinois University, Edwardsville, IL.

17. Davenport, T.E., 1984. A Review of the Sediment Delivery Ratio Techniques Component of the Highland Silver Lake Watershed Project. Illinois EPA, Springfield, IL, 27 pp.

18. Davenport, T.E., 1984. Field Modeling in the Highland Silver Lake Watershed: Interim Report. Illinois EPA, Springfield, IL, 41 pp.

19. Illinois State Coordinating Committee, 1984. Highland Silver Lake Watershed RCWP: Summary Report Fiscal Year 1984. Springfield, IL, 127 pp.

20. Davenport, T.E. and Kelly, M.H., 1984. Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project: Phase III. Illinois EPA, Springfield, IL, 216 pp.

21. Makowski, P.B. and M.T. Lee, 1985. Hydrologic Investigation of the Highland Silver Lake Watershed: 1984 Progress Report. State Water Survey Division, Champaign, IL, 68 pp.

22. Illinois State Coordinating Committee, 1985. Highland Silver Lake Watershed RCWP: Summary Report Fiscal Year 1985. Springfield, IL, 96 pp.

23. Kelly, M.H. and T.E. Davenport, 1986. Water Resource Data and Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project: Phase IV. Illinois EPA, Springfield, IL, 198 pp.

24. Makowski, P.B., M.T. Lee, and M. Grinter, 1986. Hydrologic Investigation of the Highland Silver Lake Watershed: 1985 Progress Report. State Water Survey Division, Champaign, IL, 98 pp.

25. Makowski, P.B., M. Grinter, and M.T. Lee, 1986. Stream Geometry and Streambed Material Characteristics of the Streams Within the Highland Silver Lake Watershed. State Water Survey Division, Champaign, IL, 66 pp.

26. Illinois State Coordinating Committee, 1987. Highland Silver Lake Rural Clean Water Project: Summary Report, Fiscal Year 1986. Springfield, IL, 104 pp.

27. Carvey, D. G. 1982. Highland Silver Lake Angler Opinion Survey: Preliminary Results. Economic Research Service, U.S. Department of Agriculture, East Lansing, Michigan.

28. Eleveld, B. and V. Starr. 1983. Evaluating the Effectiveness of RCWP Cost Share Payments in Illinois Through Representative Farm Analysis. Department of Agricultural Economics, University of Illinois: Champaign-Urbana, Illinois.

29. Southwestern Illinois Metropolitan and Regional Planning Commission, (1981-1985). Highland Silver Lake RCWP; Annual Reports. SIMAPC: Collinsville, Illinois.

30. White, D., B. Eleveld, and J. Braden. 1985. On-Farm Economic Impacts of Proposed Erosion Control Policies. Agricultural Economics Department, University of Illinois; Champaign-Urbana, Illinois.

V. NWQEP Project Contacts

Water Quality Monitoring
Robert L. Hite
Environmental Protection Specialist
Div. Water Pollution Control
Planning Section,IEPA
2209 W. Main Street
Marion, IL 62959
tel. (618) 997-4371

Economic Evaluation
Parveen Setia or Richard Magleby
Economic Research Service/RTD
U.S. Dept. of Agriculture
1301 New York Ave., NW, Rm. 532
Washington, DC 20005-4788
tel. (202) 786-1435

Land Treatment / Technical Assistance
Sandy Andres
S.W. Illinois Metro-area Planning Commission
203 West Main Street
Collinsville, IL 62234
tel. (618) 344-4250

PRAIRIE ROSE LAKE - RCWP 5

Shelby County, Iowa
MLRA M-107
H.U.C. 102400-020

I. Project's Major Contribution Toward Understanding the Effectiveness of NPS Control Efforts

The project shows that a very high rate of implementation is possible in a voluntary NPS control project. Factors that may contribute to the high rate of participation include: water quality objectives that are visible, substantial amounts of money available for cost sharing (approx. $163 per acre), preferred BMPs (terracing in this case), a technical assistance program, active publicity programs, and services to assist farmers in fertility management and integrated pest management.

The institutional relationships in this project could provide a model for other NPS projects. In addition, completion of the implementation and monitoring programs will provide a definitive test of the effectiveness of terracing as a BMP for protection of water quality in a small midwestern lake. (See chapter in this report for in-depth analysis of this project.)

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980 - 1991

3. **Total Project Budget:** $596,072

4. **Cost Share Budget:**
   a. Funds Allocated: $446,200
   b. Total Farmers' Contribution: $148,748 (estimated to 1991)

5. **Water Quality Monitoring Budget:** not reported

6. **Watershed Area:** 4,568 acres (Ref. 9)

7. **Project Area:** 4,568 acres (includes 433 acre park and 215 acre lake)

8. **Critical Area:** 3,920 acres (entire project area excluding park and lake)

9. **Project Land Use:**

Use	% Project Area	% Watershed Area
Cropland	92.1	79.1
Pasture/range	3.7	3.2
Woodland & parkland	0.1	14.2
Farmsteads/roads	4.0	3.5

10. **Animal Operations:** 8 (type unknown)

11. **Water Resource Type:** lake

12. **Water Uses and Impairments:**
    Prairie Rose Lake is a 215-acre man-made lake located in one of the largest parks in west-central Iowa. The lake is used for swimming, boating, and fishing by about one-quarter million park visitors each year.

The lake is impaired by sediment, turbidity and agricultural chemicals. Between 1971 and 1980, 19% of the lake volume was lost to sediment. The lake is eutrophic.

13. Water Quality at Start of Project: Upper Mixed Zone and Bottom Sites 1981 (n = 10)
(Annual means were calculated from STORET values for this project. Observations reported with less than detection limit values were set to one half the detection limit.)

Parameter	Site 1	(upper/bottom) Site 2	Site 3
Turbidity(NTU)	21 .0/ 31.0	11 .0/ 103.0	9.0 /84.1
Secchi depth (in)	16 .0/ --	21.0 /--	23.0 / --
TP (mg/l-P)*	0.12/0 .15	0.08 /0 .18	0.08 /0.16
OP (mg/l-P)*	0.04 /0.05	0.02 /0 .05	0.02 /0 .06
Chl a (ug/l)	33.7 /33.0	21.8 / 24.2	17.4 / 24.1

* TP & OP n = 5

14. Meteorologic and Hydrogeologic Factors:
a. Mean Annual Precipitation: 29.15 inches
b. USLE 'R' Factor: 150-175
c. Geologic Factors: Upland soils are generally well-drained, silty clay loams that developed in loess. Soils in the drainageways are alluvial. Slopes in the watershed range from 0-18%.

15. Water Quality Monitoring Program:
a. Timeframe: 1981 to completion of the project
b. Sampling Scheme:
1. Location and number of monitoring stations: 3 lakes stations sampled at surface and bottom
2. Sampling frequency: bi-weekly sampling summers only
3. Sample type: grab

c. Species Analyzed: $NO_3 + NO_2$, NH_4 and free NH_3, Dissolved P, TP, Sediment, DO, Chl *a*, FC, Secchi, Turbidity

16. Critical Areas: All croplands are critical acres.

17. Best Management Practices:
a. General Scheme: Most of the land treatment effort focused on controlling soil loss through practices such as terracing. Conservation tillage is encouraged, and there are I&E programs to introduce fertilizer management and integrated pest management.
b. Quantified Implementation Goals: includes non-RCWP implementation

BMP	Amount	BMP	Amount
1 Perm. veg. cover	111 ac.	9 Conservation Tillage	2,100 ac.
2 Animal waste mgmt.	6 units	11 Perm. Veg. on Crit. Acres	10 ac.
4 Terracing	75 miles	12 Sediment Control Struc.	6 units
5 Diversions	2,000 ft.	15 Nutrient Management	3,170 ac.
7 Waterway System	20 ac.	16 Pesticide Management	3,170 ac.

c. Quantified Contracting/Implementation Achievements:

Location	% under contract	% implemented
project area	83	74.0
critical area	83	74.0
critical area farms	72.0	N.A
project area farms	72.0	N.A

d. Cost of BMPs: (from RCWP Table 4, Ref. 14)

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	7.50/ac.	22.50/ac.	30/ac.
2 animal waste mgmt.	1,000 ea.	3,000 ea.	4,000 ea.
4 terraces	0.15/ft.	0.75/ft.	0.90/ft.
5 diversions	0.33/ft.	0.67/ft.	1./ft.
7 waterways	845 ea.	2,530 ea.	3,375 ea.
9 conservation tillage	5/ac.	15/ac.	20/ac.
11 perm. veg. on crit. ac.	9/ac.	21/ac.	30/ac.
12 sediment retention & erosion control struc.	2,500 ea.	7,500 ea.	10,000 ea.

e. Effectiveness of BMPS: Soil loss has decreased from 80,800 tons/year (1980) to 36,900 tons/year (1985). Data from three bathymetric surveys indicate a reduction in sedimentation rate. Confirmation of this trend, however, depends on completing the fourth bathymetric survey planned at the conclusion of the RCWP project.

18. Water Quality Changes:

There has been no documented decrease in turbidity since the RCWP began. The project's water quality monitoring data indicate high variability with no consistent trend in surface turbidity and water clarity. Chlorophyll *a* concentration may explain a large portion of this variability, and improved clarity may be masked by increasing algal growth.

19. Changes in Water Resource Use:

Total recreational use of the lake increased from 1981 to 1985 before declining in 1986 to the lowest level since 1981. Fishing use decreased from 1981 to 1983, following a total fishery renovation, but increased from 1983 to 1985. Use of the swimming beach also increased annually from 1981 to 1985. The project notes that increased swimming use may have been a reflection of improved public perception of lake aesthetics. Construction on the park access road in the latter part of 1985 may have depressed the annual increase of park visitors and contributed to decreased user totals in 1986. The sudden decline in lake use in 1986 may be attributable to the institution of a state park user fee, predominantly wet weather, and additional roadway construction.

20. Incentives:

a. Cost Share: Rates are generally 75%, except for nutrient management and pesticide management, which are handled under the I&E program and are not cost shared.
b. $ Limitation: $50,000 per farm
c. Assistance Programs: Extensive I&E program handles all the nutrient and pesticide management in the project (program conducted by the Extension Service).

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
1) Recreation: $30,000 - $85,000 per year
2) Water supply: 0 - $45,000 per year
3) Commercial fishing: 0
4) Wildlife habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream impacts: 0

III. Lessons Learned

A high rate of BMP implementation is possible when water quality objectives are clear and where the practices are considered desirable by the landowners. In this case, the farmers recognize the need for terracing to prevent soil erosion, and they believe this will improve the quality of the recreational lake. Assistance in the form of cost sharing, soil testing, and pest scouting provided enough incentive to promote this project. Recreational use of the lake has increased during the project period. This may be at least partially attributable to the attention it has received for the RCWP project. Some water quality improvement has apparently been perceived by lake users, although water quality data do not yet confirm this.

Reduction of the sedimentation problem by extensive adoption of conservation practices (primarily terracing) may have improved water clarity, but this appears to have allowed algal density to increase. Evidence to date suggest that BMPs have not reversed eutrophication.

The project has met its implementation goals, and the monitoring program has been consistent throughout the project period. Water quality effects attributable to erosion control should be documented by the end of the implementation period in 1991.

Positive net economic benefits are possible when treating sediment which adversely affects recreation.

IV. Project Documents

1. Prairie Rose Lake RCWP Application. July 1979.
2. Prairie Rose Lake RCWP Supplement to Application. Monitoring and Evaluation Plan. August 1979.
3. EPA Comments on Work Plan. June 2, 1980.
4. Experimental RCWP Plan of Work, Prairie Rose Lake Watershed. June 1980.
5. Prairie Rose Lake. Plan of Work-Amendment 2. September 5, 1980.
6. Prairie Rose Lake Monitoring RCWP Project-Year 1 (1981). March 23, 1982. 3,-4,-5, and SCS Report of Project Accomplishments.
7. Corrections and Additions to the Report Entitled "Prairie Rose Lake Monitoring RCWP-Project-Year 1 (1981), March 23, 1982".
8. Prairie Rose Lake Monitoring RCWP Project-Year 2 (1982). October 19, 1982.
9. 1982 Annual Report. November 30, 1982.
10. 1983 Annual Report. November 30, 1983.
11. 1984 Annual Report. November 30, 1984 (Includes Lake Monitoring Report).
12. 1985 Annual Report. November 30, 1985.
13. Prairie Rose Lake Monitoring RCWP Project-Year 5 (1985). April 9, 1986.
14. 1986 Annual Report. November 30, 1986.
15. Prairie Rose Lake Monitoring RCWP Project - Year 6 (1986).

V. NWQEP PROJECT CONTACTS

Water Quality Monitoring
Monica Wnuk
Iowa Dept. of Natural Resources
900 E. Grand Ave.
Des Moines, IA 50319
tel. (515) 281-8879

Land Treatment/Technical Assistance
Merle Lawyer
SCS
1112 Morningview Dr.
RR# 4
Harlan, IA 51537
tel. (712) 755-2417

Information and Education

Duane R. Feltz
Shelby County Extension Service
1105 8th Street
Harlan, IA 51537
tel. (712) 755-3104

BAYOU BONNE IDEE - RCWP 7

Morehouse Parish, Louisiana
MLRA: O-134
H.U.C. 080500-01

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project's primary contribution will be to document the rate of organo-chlorine residue dissipation from an agricultural watershed.

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1980-1991

3. Total Project Budget (excludes water quality monitoring funds and farmers' contributions): $5,159,000

4. Cost Share Budget:
a. Funds Allocated: $3,930,000
b. Total Farmers' Contributions: $1,956,000 estimated as of 1990

5. Water Quality Monitoring Budget: $722,000

6. Watershed Area: 66,000 acres

7. Project Area: 66,000 acres

8. Critical Area: 44,880 acres

9. Project Land Use:

Use	% project area
cropland	74.4
pasture/range	4.0
woodland	11.3
urban/roads	10.3

10. Animal Operations in Project Area: not applicable

11. Water Resource Type: Bayou Bonne Idee

12. Water Uses and Impairments:
Bayou Bonne Idee is used mainly for water sports and fishing. It is popular for recreation that contributes significantly to the local economy. Approximately 10,000 people use the Bayou for fishing and water sports each year. Use of project area water resources has declined due to poor water quality attributed to pesticides in runoff from surrounding cropland.

13. Water Quality at Start of Project: organo-chlorine pesticide concentrations of about 0.5 ppm in fish tissue samples

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 48 inches

b. USLE 'R' Factor: 350

c. Geologic Factors: The project area is in the Arkansas River Alluvial Plain within the Southern Mississippi Valley Alluvium Major Land Resource Area. Topography is nearly level to gently sloping.

15. Water Quality Monitoring Program:

a. Timeframe: 1980 - 1990

b. Sampling Scheme

1. Location and Number of Monitoring Stations: 5 bayou stations
2. Sampling Frequency: monthly - water; bi-annual-fish tissue
3. Sample Type: grab

c. Pollutants Analyzed: 27 pesticides plus 26 conventional parameters

d. Flow Measurements: Instantaneous flow measurements are taken with each grab sample.

16. Critical Areas:

a. Criteria: Three-quarter mile proximity to Bayou Bonne Idee, all cotton land.

b. Application of Criteria: No information available on how strictly criteria have been applied.

17. Best Management Practices:

a. General Scheme: Treatment emphasizes furrow irrigation improvements and field borders.

b. Quantified Implementation Goals: Goal is to treat 2/3 of cropland acreage.

c. Quantified Contracting/Implementation Achievements:

Location	% under contract	% implemented
project area	41	30(approx.)
critical area	60	42
critical area farms	70.6	50
project area farms	56.4	NA

d. Cost of BMPs:

BMP	Ave. RCWP Share ($)	BMP	Ave. RCWP Share ($)
1 Fencing	0.26/ft.	11 Field Border	17/ac.
4 Terraces	1.08/ft.	11 Filter Strip	55/ac.
7 Grassed Waterways	960/ac.	12 Grade Stabilization Struc.	440 ea.
8 Green Manure Crop	31/ac.	12 Heavy Use Struc.	1,430 ea.
9 Land Smoothing	350/ac.	13 Irrig. Land Leveling	170/ac.
9 Crop Residue Use	3/ac.	13 Irrig. Water Conveyance	2.50/ft.
9 Conservation Tillage	33/ac.	15 Fert. Management	2.50/ft.
11 Critical Area Veg.	44/ac.	16 Pest Management	1.30/ac.

e. Effectiveness of BMPs: not available

18. Water Quality Changes:

Turbidity levels in Bonne Idee were higher in 1984-1985 than in 1980-83, but this may be due to manipulation of Bayou water levels. Toxaphene concentrations in fish tissue have dropped dramatically since 1980. This appears to be due to the use of synthetic pyrethroids to replace toxaphene on cotton. The estimated half-life of toxaphene in fish tissue is about one year. No water quality report was included in the project's 1986 Annual Progress Report.

19. Changes in Water Resource Use:

Currently, an estimated 10,000 recreational fisherman use the project area water resources each year.

20. Incentives:

a. Cost Share Rates: 75% for soil conservation practices, 50% for irrigation improvements and 90% for farmers located adjacent to the Bayou Bonne Idee

b. $ Limitations: $50,000 maximum

c. Assistance Programs: none

21. Potential Economic Benefits:

a. On-farm: not evaluated

b. Off-farm:

1) Recreation: 0 - $40,000 per year.
2) Water supply: 0
3) Commercial fishing: 0
4) Wildlife habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream impacts: 0

III. Lessons Learned

1. The original 220,000 acre project area was much too large to achieve adequate BMP coverage.
2. High participation levels can be achieved at fairly low cost share rates (50%) for practices which are perceived to have significant productivity benefits.
3. Practices that have primarily off-site benefits can be tacked onto contracts that include practices with high on-site benefits such as irrigation improvements.
4. Treating a large project area will not result in high off-farm benefits unless impaired water uses are substantial.

IV. Project Documents

1. Bayou Bonne Idee RCWP Annual Progress Report, 1982.

2. Bayou Bonne Idee RCWP Annual Progress Report, 1983.

3. Bayou Bonne Idee RCWP Annual Progress Report, 1984.

4. Bayou Bonne Idee RCWP Annual Progress Report, 1985.

5. Bayou Bonne Idee RCWP Annual Progress Report, 1986.

V. NWQEP Project Contacts

Water Quality Monitoring

Kent Milton
USDA - SCS
3737 Government Street
Alexandria, LA 71302
tel. (318) 473-7808
and
Lewis Johnson
Louisiana Dept. of Env.Quality
Baton Rouge, LA
tel. (318) 342-6363

Land Treatment/Technical Assistance

Bennett C. Landreneau
USDA - SCS
3737 Government Street
Alexandria, LA 71302
tel. (318) 473-7759
and
Harry Hawthorne
(same address as above)

DOUBLE PIPE CREEK - RCWP 8

Carroll County, Maryland
MLRA: S-148
H.U.C. 020700-09

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

This project's water quality monitoring has contributed little information to date. The critical area is very small and clearly designated, allowing efficient I & E and technical assistance efforts. Also, there has been a significant shift in BMP emphasis to conservation tillage, without RCWP funding, in the project area.

II. Project's Characteristics and Results

1. Project Type: RCWP

2.Timeframe:1980-1991

3. Total Project Budget (excludes water quality monitoring funds and farmers' contributions): $5,118,051

4. Cost Share Budget:
a. Funds Allocated: $3,730,800
b. Total Farmers' Contributions: $1,463,200 estimated as of 1990

5. Water Quality Monitoring Budget: not available

6. Watershed Area: 110,000 acres

7. Project Area: 110,000 acres

8. Critical Area: 18,180 acres

9. Project Land Use:

Use	% project area
cropland	65
pasture/range	12
woodland	15
urban/roads	8

10. Animal Operations in Project Area:
a. Dairy:19,774 a.u.
b. Beef: 6,958 a.u.
c. Swine: 6,222 a.u.
d. Poultry: 5,000 a.u.
e. Horses: 7,747 a.u.

11. Water Resource Type: streams

12. Water Uses and Impairments:
Project area streams and ponds provide public water supply for the city of Westminster and surrounding areas, approximately 18,000 people and several businesses. Secondary uses of water resources are contact recreation and fishing.

Water quality impairments are caused by suspended sediment and bacteria. There is also concern about nutrient export to the Chesapeake Bay.

13. Water Quality at Start of Project:

Maximum FC bacteria concentrations were 40,000/100 ml. Turbidity after runoff events was often greater than 100 ntu.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 45 inches

b. USLE 'R' Factor: 200

c. Geologic Factors: The project area lies within the north central Piedmont Region and is characterized by gently rolling to steep uplands with streams of average to steep gradient feeding into the bottomlands. Predominant soils are moderately erodible. Ground water within the project area occurs primarily in fractures and bedding-plane partings of rocks. It may also occur in solutional cavities in limestone and marble.

15. Water Quality Monitoring Program:

a. Timeframe: 1980 - 1990

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: four on-farm sites; one station at downstream terminus of project area.
2. Sampling Frequency: nine storms/yr.
3. Sample Type: automatic

c. Pollutants Analyzed: suspended sediment, fecal coliform, NH_3, NO_3, TKN, P-total, P-ortho

d. Flow Measurements: continuous

16. Critical Areas:

a. Criteria: distance from major streams, size of farm operation, present conservation status

b. Application of Criteria: no evidence that criteria have been rigorously applied

17. Best Management Practices:

a. General Scheme: Treat cropland with conservation tillage and install grassed waterways; build waste storage structures for critical animal operations and spread manure based on soil tests.

b. Quantified Implementation Goals: 13,635 acres (12% of project area)

c. Quantified Contracting/Implementation Achievements:

Location	% under contract	% implemented
project area	19.6	~10
critical area	159.0*	~70
critical area farms	60	~35

*figure represents 100% of designated critical areas plus other contracted acres

d. Cost of BMPs: (from RCWP Table 4, Ref. 8)

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	48/ac.	72/ac.	120/ac.
2 animal waste mgmt.	6,500 ea.	19,500 ea.	26,000 ea.
3 stripcropping	5/ac.	15/ac.	20/ac.
5 diversions	0.55/ft.	1.70/ft.	2.25/ft.
6 grazing land prot.	625-5,850 ea.	1,875-5,850 ea.	2,500-11,700 ea.
7 waterways	1.50/ft.	4.50/ft.	6/ft.
8 cropland prot.	12.50/ac.	12.50/ac.	25/ac.
9 conservation tillage	18/ac.	0/ac.	18/ac.

(continued on next page)

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
10 stream prot.	860/ea.	2,600 ea.	3,460 ea.
11 perm. veg. on crit. ac.	165/ac.	160/ac.	325/ac.
12 sediment retention, erosion control struc.	875 ea.	2,625 ea.	3,500 ea.
15 fertilizer mgmt.	0.25/ac.	0.75/ac.	1/ac.
16 pesticide mgmt.	1.50/ac.	4.50/ac.	6/ac.

e. Effectiveness of BMPs: 18,427 tons soil saved per year / 3,267,357 cu.ft. of animal waste stored per year

18. Water Quality Changes:

No water quality changes have been documented to date. Three farm sites that had intensive pre-BMP monitoring were discontinued because the farm operator withdrew his support.

19. Changes in Water Resource Use:

There are no documented changes in water resource use. There is very little recreational use and the cost of water treatment for the City of Westminster has not changed since RCWP began.

20. Incentives:

a. Cost Share Rates: 75% for most practices
b. $ Limitations: $50,000
c. Assistance Programs: Several landowners have been assisted through ACP.

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
1. Recreation: 0
2. Water Supply (cost saved in treatment): 0
3. Commercial Fishing: 0
4. Wildlife Habitat: unknown
5. Aesthetics: unknown
6. Downstream Impacts: unknown but positive. As part of a larger effort to improve water quality in the Chesapeake Bay the project could generate off-site benefits.

III. Lessons Learned

Project may be a good test of whether an observable pollutant reduction can be achieved by treating specified critical areas that comprise only about 20% of the watershed.

Project personnel consciously directed recruitment efforts to the large producers. The level of treatment indicates that this was an effective strategy.

Several years and much money were spent monitoring three specific 17-175 acre farm sites. It now appears that all three of these farms will not implement BMPs. This illustrates the importance of developing a binding contract with landowners whose participation is essential to the project even if it means providing crop insurance or inconvenience payments to the landowner.

IV. Project Documents

1. Rural Clean Water Project: Double Pipe Creek Water Quality Plan of Work 1980 - 1995, 1980.

2. Double Pipe Creek Project: Carroll County Maryland, Annual Progress Report, 1983.

3. Non-Point Source Water Quality Assessment Of Monocacy River Basin With Special Attention to the Double Pipe Creek Watershed. Versar Inc., 1983.

4. Rural Clean Water Project: Double Pipe Creek Water Quality Plan of Work 1980 - 1995 (Revised), 1983.

5. Rural Clean Water Project: Double Pipe Creek Project, 1984 Progress Report, 1984.

6. Rural Clean Water Project: Double Pipe Creek Project, 1985 Progress Report, 1985.

7. Results of the Nonpoint Source Water Quality Program Conducted in the Monocacy River Basin With Special Attention to the Double Pipe Creek Watershed. Versar Inc., February 1986.

8. Rural Clean Water Program: Double Pipe Creek Project, 1986 Plan of Work and Progress Report, 1986.

V. NWQEP Project Contact

Water Quality Monitoring

Karl Weaver
Water Management Administration
Maryland Department of the Environment
P.O. Box 13387
Baltimore, MD 21203
tel. (301) 225-6285

SALINE VALLEY - RCWP 9

Washtenaw County, Michigan
MLRA: M - 111 and L-99
H.U.C. 041000-01

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

Although no major contributions have yet been made, we believe that within the next 1-2 years this project may be one of the first to document basin level (1000-8000 acres) phosphorus reductions from cropland treatment. (See chapter on this project for in-depth analysis.)

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1980-1990

3. Total Project Budget (excludes water quality monitoring funds and farmers' contributions): $ 2,545,870
- a. Funds Allocated: $ 1,888,106
- b. Total Farmers' Contributions: $629,386 estimated as if 1990

5. Water Quality Monitoring Budget: $200,000 estimated

6. Watershed Area: 77,000 acres

7. Project Area: 77,000 acres

8. Critical Area: 32,000 acres (approx.)

9. Project Land Use:

Use	% project area
cropland	66.4
pasture/range	10.4
woodland	20.8
urban/roads	2

10. Animal Operations in Project Area:
- a. Dairy: 4,193 a. u.
- b. Beef: 816 a. u.
- c. Swine: 172 a. u.
- e. Horses: 141 a. u.

11. Water Resource Type: streams and river draining to Lake Erie

12. Water Uses and Impairments:

Water resources in the project area are used for recreation and public water supply. Water quality impairments are caused by high nutrient concentrations and sedimentation.

13. Water Quality at Start of Project:

Eutrophic streams. Ortho-P concentrations about 0.1 mg/l. Highest per acre P loading to Lake Erie of any watershed in the area.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 32 inches

b. USLE 'R' Factor: 125

c. Geologic Factors: Project area soils vary from clay loam to organic deposits to sand. Glacial moraines run through the center of the project area. Steep slopes occur on about 20% of the farmland.

15. Water Quality Monitoring Program:

a. Timeframe: 1980 - 1990

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: 9 tributary and river stations
2. Sampling Frequency: weekly
3. Sample Type: grab

c. Pollutants Analyzed: TSS, Ortho-P, Total P, NO_3, NH_3, turbidity

d. Flow Measurements: weekly

e. Other: biomonitoring using diatoms

16. Critical Areas:

a. Criteria: All cropland and animal operations within 1/4 mile of perennial watercourses.

b. Application of Criteria: Strict adherence to criteria.

17. Best Management Practices:

a. General Scheme: nutrient loading reduction from animal waste manage, conservation tillage, and fertilizer management

b. Quantified Implementation Goals: 31,824 acres, 27 animal operations

c. Quantified Contracting/Implementation Achievements:

Location	% under contract	% implemented
project area	18.6	~15
critical area	45.1	~40
critical area farms	32.8	~30
project area farms	32.8	~30

d. Cost of BMPs: not available by BMP

18. Water Quality Changes:

No water quality changes have yet been documented; however, seasonal trends have been clearly established.

19. Changes in Water Resource Use:

There has been no documented change in recreational use and there is no documented water supply impairment. Recreational use of the project area continues to be low.

20. Incentives:

a. Cost Share Rates: 75% for most practices

b. $ Limitations: $50,000 maximum

c. Other Incentives or Regulations: conservation tillage demonstration fields

21. Potential Economic Benefits:

a. On-farm: not evaluated

b. Off-farm:

1) Recreation: 0
2) Water Supply: 0
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: unknown but positive

III. Lessons Learned

The original 200,000 acre project area was too large to achieve adequate BMP coverage with the available cost share funding and technical assistance personnel.

BMP effects can only be observed in the project if monitoring focuses on smaller subbasins with a high level of BMP implementation.

IV. Project Documents

1. Saline Valley Rural Clean Water Project, Michigan. Revised Plan of Work, July 1983.

2. Saline Valley Rural Clean Water Project, Michigan. Annual Progress Report, 1984.

3. Saline Valley Rural Clean Water Project, Michigan. Annual Progress Report, 1985.

4. Holland, R. E., A.M. Beeton and D. Conley. Saline Valley Rural Clean Water Project Interim Report on Monitoring. Great Lakes and Marine Waters Center. October 1985.

5. Saline Valley Rural Clean Water Project, Michigan. Annual Progress Report, 1986.

6. Johengen, T. H., Documenting the Effectiveness of Best Management Practices to Reduce Agricultural Nonpoint Source Pollution. University of Michigan, Department of Atmospheric and Oceanic Sciences. Ann Arbor, MI. 1987.

V. NWQEP Project Contacts

Water Quality Monitoring

Mr. Thomas Johengen
Dept. of Atmospheric and Oceanic Sciences
University of Michigan
Ann Arbor, MI 48109

Land Treatment/Technical Assistance

Robert Payne
ASCS
1405 S. Harrison Rd.
Room 1116
Fort Lansing, MI 48823
tel. (517) 337-6671

and

Gary Rinkenberger
Soil Conservation Service
6101 Jackson Rd.
Ann Arbor, MI 48103
tel. (313) 761-6722

REELFOOT LAKE - RCWP10

Obion and Lake Counties, Tennessee
and Fulton County, Kentucky
MLRA: 0-131 and P-134
H.U.C. 080102-02

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project is an example of interagency and interstate cooperation in a NPS project. However, with the implementation of the PL-566 project in the RCWP project area, it is not possible to monitor the effectiveness of BMP land treatment for erosion control.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980-1990

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): $ 4,198,026

4. **Cost Share Budget:**
   a. Funds Allocated: $3,727,784
   b. Total Farmers' Contributions: $1,175,926 estimated

5. **Water Quality Monitoring Budget:** $20,000

6. **Watershed Area:** 153,600 acres

7. **Project Area:** 153,600 acres

8. **Critical Area:** 52,072 acres

9. **Project Land Use** (equivalent to watershed land use): (ref. 2, p. 7)

use	% project area
cropland	41
pasture/range (grassland)	19
woodland	20
urban/roads	1
water and wetlands	12
state park and wildlife refuges	7

10. **Animal Operations in Project Area:** not applicable

11. **Water Resource Type:** streams with a receiving lake, Reelfoot Lake

12. **Water Use Impairment:**
    Reelfoot Lake is located in a popular state park in Tennessee used primarily for fishing, boating, and waterfowl hunting. The park had over 850,000 visitors during fiscal year 1974 (ref. 2). Other water uses within the project area are irrigation and livestock watering.

Impairments of Reelfoot Lake are: decreased lake volume, decreased fishery and wildlife habitat, and impaired recreational use caused mainly by sediment and high nutrient concentrations. The lake has a severe eutrophication problem. Pesticides are reported to be a cause of impairment, but data do not support this claim.

13. Water Quality at Start of Project: (ref. 7, pp.39-42A)

Concentrations (mg/l) at Lake Sites (1977-1982)

Parameter	Station 1 (open water)	Station 2 (near outflow)	Station 4 (near creek confluence)
	x – n	x – n	x – n
Suspended solids	33–8	27–7	26–7
Phosphates[1]	0.16–8	0.20–8	0.12–8
TKN	1.53–5	2.02–6	0.97–6
NO-3 & NO-2	0.05–8	0.09–8	0.04 –8

[1] Species not noted.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: ~48 inches

b. USLE 'R' Factor: ~260

c. Geologic Factors: The project area lies within the Mississippi embayment section of the Gulf Coastal Plain. Uplands and bottomlands are divided by a distinct bluff running north-south through the area. Substrate consists primarily of compact silt and clay mixtures. Bottomlands are covered by deep alluvial deposits of silt, clay, sand and gravel. Uplands are covered by fluvial gravels topped with silty loess. Predominant soils are moderately well-drained to somewhat poorly drained loams. All soils in the area are highly susceptible to gully and sheet erosion. Topography is nearly level on uplands to steeply sloped along bluffs adjacent to the lake.

15. Water Quality Monitoring Program:

a. Timeframe: 1981 to 1995

b. Sampling Scheme:

1. Lake Monitoring: Six stations are sampled twice a year (May and October). Four stations are near confluences of tributaries, one is near the outflow and the other in open water.
2. Tributary Monitoring: Three stations representing the three main tributaries in the watershed are grab sampled monthly (9 to 12 times per year). In addition, the major outflow of the lake is monitored for flow only.
3. Sample Type: Five ungaged stream sites are grab sampled three times per year.

c. Pollutants Analyzed:

1. Lake Monitoring--BOD, DO, Secchi disk, Chl *a*, pH, temperature, suspended solids, dissolved solids, settleable solids, total solids, NO_2 and NO_3, phosphates, algal growth, potential pesticides (only once per year), including fish tissue and those adsorbed to sediment.
2. Tributary Monitoring: suspended solid settlement--monthly; pesticides (water)--quarterly; pesticides (bed materials)--twice per year
3. Ungaged Stream Sites: Suspended sediment

d. Flow Measurements:

1. Tributary monitoring: Continuous flow measurements
2. Ungaged stream sites: Instantaneous flow measurements at time of sampling

16. Critical Areas:

a. Criteria: Currently, 83% of the cropland is designated as critical and is prioritized in three classifications based on cropping intensity, erosion rate, and proximity to the lake and streams.

b. Application of Criteria: Contracts are being obtained for critical areas but reports do not indicate if the prioritization of critical areas is being followed.

17. **Best Management Practices:**

a. General Scheme: Land treatment emphasized by this project includes erosion controls (e.g. conservation tillage), stream protection, fertilizer and pesticide management. These include RCWP BMPs 1-16, excluding 13.

b. Quantified Implementation Goals:

1. Treat 80% of critical area (41,658 acres)
2. Reduce sediment delivered to the lake by 75%, which is equivalent to sediment reduction of 638,019 tons/year.

c. Quantified Contracting/Implementation Achievements: as of September, 1986 (ref. 11, p. 15)

location	% under contract	% implemented
project area	18	12
critical area	53	35
critical area farms	61	NA
project area farms	NA	NA

d. cost of BMPs: Not available by BMP.

e. Effectiveness of BMPs: None have been reported to date.

18. **Water Quality Changes:**

None have been reported to date. With the ACP and extensive PL-566 project with the RCWP project area, the monitoring program will not document the water quality impacts of RCWP alone.

19. **Changes in Water Resource Use:**

There are no documented changes in water use at Reelfoot Lake since RCWP began. However, if the installed BMPs reduce sediment, then the loss of lake capacity and severity of recreational impairments may be reduced.

20. **Incentives:**

a. Cost Share Rates: 75%

b. $ Limitations: $50,000 per landowner

c. Assistance Programs: TN will conditionally pay the other 25% cost share to establish alfalfa on designated steep, erodible lands within the project area.

d. Other Incentives or Regulations: The Conservation Reserve Program provides additional incentives to farmers to convert highly erodible lands to more permanent vegetation.

21. **Potential Economic Benefits:**

a. On-farm: not evaluated

b. Off-farm:

1) Recreation: 0 - $30,000 per year
2) Water Supply: 0 - $2,000 per year
3) Commercial fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: 0

III. Lessons Learned

Interstate cooperation is an essential element for the success of this project. Not only is the apparent cooperation between the two states good, but the cooperative efforts of several programs (local, state, and federal) also appear worthy of examination as a model of how multiple agencies can coordinate to address a common water quality goal.

IV. Project Documents

1. Tennessee Department of Public Health, Division of Water Quality Control, 1978. Reelfoot Lake Pesticide Survey, Lake and Obion Counties.

2. Application for RCWP Grant, Reelfoot Lake Drainage Area, 1979. 57pp.

3. USDA-Soil Conservation Service, 1979. Land Treatment Plan for Erosion Control and Water Quality Improvement, Reelfoot Lake Drainage Area. 34pp.

4. Reelfoot Lake RCWP Project Plan of Work, 1980.

5. Tennessee Department of Public Health, Division of Water Quality Control, 1981. Monitoring and Evaluation Plan Reelfoot-Indian Creek Watershed RCWP. 21pp.

6. Smith, W.L. and T.D. Pitts, 1982. Reelfoot Lake: Summary Report. University of Tennessee, Martin, TN. 128pp.

7. Local Coordinating Committee Reelfoot Lake RCWP, 1982. Reelfoot Lake RCWP Annual Progress Report. 151pp.

8. Local Coordinating Committee Reelfoot Lake RCWP, 1983. Reelfoot Lake RCWP Annual Progress Report.

9. Local Coordinating Committee Reelfoot Lake RCWP, 1984. Reelfoot Lake RCWP Annual Progress Report.

10. Local Coordinating Committee Reelfoot Lake RCWP, 1985. Reelfoot Lake RCWP Annual Progress Report.

11. Local Coordinating Committee Reelfoot Lake RCWP, 1986. Reelfoot Lake RCWP Annual Progress Report.

V. NWQEP Project Contact

Water Quality Monitoring & Land Treatment

Louis Godbey
Soil Conservation Service
U.S. Court House
Room 675
801 Broadway Street
Nashville, TN 37203

SNAKE CREEK - RCWP 11

Wasatch County, Utah
MLRA: E-47
H.U.C. 160202-03

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

This project adds information on the effectiveness of BMPs in arid, irrigated areas and the effectiveness of animal waste management systems. The project accomplished nearly complete BMP implementation over a small area. Significant reductions in phosphorus concentration (40-65%), nitrogen concentration (45- 60%), and fecal coliform bacterial densities (50-90%) followed animal waste BMP implementation. These results were documented with five years of water quality data (two years pre-implementation, one year during implementation, and two years post-implementation), a much shorter period than generally required to document effectiveness for projects in humid, non-irrigated regions.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980-1990

3. **Total Project Budget:** (excludes water quality monitoring funds and farmers' contributions) $242,400

4. **Cost Share Budget:** (1983 Progress Report, RCWP 5)
   a. Funds Allocated: $161,000
   b. Total Farmers' Contributions: $64,850

5. **Water Quality Monitoring Budget:** $191,230

6. **Watershed Area:** 523,403 acres (Deer Creek Reservoir Watershed)

7. **Project Area:** 700 acres

8. **Critical Area:** 489 acres

9. **Project Land Use and Watershed Land Use:** (ref. 4, p. 16-17, and ref.6, p.5)

use	% project area	% watershed area
cropland (mostly alfalfa)	90	6
pasture/range	4	37
woodland	0	0
urban/roads	6	3
multiple use	0	54

10. **Animal Operations in Project Area:**
    a. Dairy: 4 farms with a total of 650 a.u in 1981 and 790 a.u. in 1983
    b. Beef: 4 farms with a total of 100 a.u.
    c. Horse: 2 farms with a total of 35 a.u.

11. **Water Resource Type:** The water resources are irrigation canals draining into Snake Creek which flows into the Provo River slightly upstream from the river's discharge into Deer Creek Reservoir.

12. Water Uses and Impairments:

Water is stored in Deer Creek Reservoir, located just outside of the project area, primarily for municipal, industrial and irrigation use in neighboring valleys. Recreational use of the reservoir is also important (351,571 visitors during 1978 - ref. 1). About 500,000 people in the Salt Lake Valley received potable water from the reservoir when the project began in 1980.

The reservoir has a eutrophication problem which impairs its use for water supply and recreation. High concentrations of fecal coliform bacteria and phosphorus occur frequently in Snake Creek; however, Snake Creek is a relatively minor source of the total pollutants entering Deer Creek reservoir (ref. 10).

13. Water Quality at Start of Project: Nov. 1979 to Dec. 1981 (ref.4)

	Station 14 (Snake Creek near base of project area)				Station 6 (ditch downstream from dairy farm)			
	min.	max.	mean	n	min.	max.	mean	n
TP (mg/l)	0.02	0.71	0.14	33	0.04	0.56	0.19	31
TKN (mg/l)	0.10	3.90	0.851	33	0.10	4.60	1.08	31
FC (#/100ml)*	30.00	7500	889	13	19.00	12,800	1762	10

* Feb. 1981-Dec. 1981 only

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 16.4 inches

b. USLE 'R' Factor: ~30

c. Geologic Factors: The project area is in a valley which has a floor underlain by beds of unconsolidated material from 40 to over 1,000 feet deep. Soils range from well drained deep soils formed in alluvium and residium from sedimentary rocks on foothills and alluvial fans to moderately well drained and poorly drained deep soils formed in mixed alluvium on flood plains, low stream terraces and valley bottoms. Surface drainage patterns indicate that all surface water entering the valley runs in a direct manner toward the reservoir adjacent to the project area.

15. Water Quality Monitoring Program:

a. Timeframe: Nov. 1979 - 1990

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: Initially, the project monitored water quality at 20 stations along Snake Creek, Provo River and several irrigation ditches. As of 1986, monitoring has been reduced to seven stations.
2. Sampling Frequency: monthly, with weekly samples taken during spring runoff.
3. Sample Type : grab

c. Pollutants Analyzed: TP, OP, TKN, NO_3, NO_2, NH_3, BOD, TSS, TDS, conductivity, temperature, and pH

d. Flow Measurements: instantaneous at time of sampling

16. Critical Areas:

a. Criteria: Since this is a small project area, all major animal operations were considered critical.

b. Application of Criteria: adequate

17. Best Management Practices:

a. General Scheme: Project proposed to install animal waste management systems (BMP 2) on all farms in the project area.

b. Quantified Implementation Goals: Contracts were planned for all four dairies and two of the beef operations in the project area; the other two beef operations had agreed to use conservation methods without the aid of the RCWP project. The two horse operations were not considered critical and were not included in the contracting plans.

c. Quantified Contracting/Implementation Achievements: as of December, 1986 (ref. 8)

6 contracts have been completed.

d. Cost of BMPs: Cost shares not available by BMP.
e. Effectiveness of BMPs: Examination of recent data indicates continued water quality improvement.

18. Water Quality Changes:
Significant water quality improvements attributable to BMP implementation have been reported (ref. 9, p. 101). On the main reach of Snake Creek, analysis showed 43 to 90% reduction in TP, OP, TKN and FC concentrations. Recent data (1985 and 1986) from stations 10 and 14 indicate continued water quality improvement. Analysis of Huffaker Ditch (ref. 9, p. 101) shows a 48 to 66% reduction in TP, OP, TKN, and FC concentrations attributable to BMP implementation. No significant water quality impact on Deer Creek Reservoir is expected from this project, however, because the project area constitutes less than 1% of the reservoir drainage. (For further discussion see appendix to NWQEP Annual Report, 1985.)

19. Changes in Water Resource Use:
Actual visitation appears to have increased as a result of opening the park for year-round use. The reservoir is still used as a primary water supply for several nearby towns and is considered to be of good quality.

20. Incentives:
a. Cost Share Rates: 75%
b. $ Limitations: $50,000 per landowner
c. Assistance Programs: none reported

21. Potential Economic Benefits:
a. On-farm: not evaluated
b. Off-farm:
1) Recreation: 0
2) Water Supply: $4,000 per year.
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown
6) Downstream impacts: 0

III. Lesson Learned

This project not only was successful in reducing nutrient and bacterial concentrations, but also was exemplary for its region. Other dairies in the Heber Valley area now are considering installing similar practices after seeing the success of the Snake Creek RCWP. However, treating only a small project like this RCWP is unlikely to benefit a large reservoir downstream unless other projects are also initiated.

The small area of this project made it ideal for nearly complete implementation and ease of tracking. Water quality data analyses by NWQEP identified two critical areas: one small reach of the Snake Creek and Huffaker Ditch. These analyses also indicated that it may not have been necessary to install practices outside of these two critical areas.

IV. Project Documents

1. Mountain Land Association of Governments, 1979. Application for Rural Clean Water Program Funds, Snake Creek, Wasatch County, Utah. 34 pp.

2. Snake Creek Experimental Rural Clean Water Program, 1980. Plan of Work. 25pp.

3. Mountainland Association of Governments, 1980. Snake Creek RCWP Monitoring Study Progress Report. Provo, Utah. 53pp.

4. Snake Creek Local Coordinating Committee, 1982. Annual Progress Report on the Snake Creek Rural Clean Water Program. Wasatch County, Utah.

5. Snake Creek Local Coordinating Committee, 1983. Annual Progress Report on the Snake Creek Rural Clean Water Program. Wasatch County, Utah.

6. Snake Creek Local Coordinating Committee, 1984. Annual Progress Report on the Snake Creek Rural Clean Water Program. Wasatch County, Utah.

7. Snake Creek Local Coordinating Committee, 1985. Annual Progress Report on the Snake Creek Rural Clean Water Program. Wasatch County, Utah.

8. Snake Creek Local Coordinating Committee, 1986. Annual Progress Report on the Snake Creek Rural Clean Water Program. Wasatch County, Utah.

9. NWQEP 1986 Annual Report: Status of Agricultural NPS Projects, National Water Quality Evaluation Project. Biological and Agricultural Engineering Department, North Carolina State University.

10. Sowby and Berg Consultants. Deer Creek Reservoir and Proposed Jordanelle Reservoir Water Quality Management Plan. Prepared for Wasatch and Summit Counties, Provo, Utah. (1984)

V. NWQEP Project Contacts

Water Quality Monitoring
Ray Loveless
Utah Mountain Land Association of Governments
2545 N. Canyon Rd.
Provo, UT 84604
tel. (801) 377-2262

Land Treatment
Jack Young
USDA - SCS
P.O. Box 87
Heber City, UT 84032
tel. (801) 654-0242

Land Treatment/Technical Assistance
Mr. Tracy Hicken, Chairman
Local Coordinating Committee
Snake Creek RCWP
Wasatch County ASCS Office
P.O. Box 6
Heber City, Utah 84032
and
Bryant Brady
USDA-SCS
Heber City, UT 84032
tel. (801) 377-5580

ST. ALBANS BAY - RCWP 12

Franklin County, Vermont
MLRA: R-142
H.U.C. 020100-05,07

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts:

This project has made substantial contributions in the following areas:

a) Water Quality Monitoring: The project has provided information on the level of monitoring needed to detect changes in watershed nutrient loadings and concentrations and design of watershed monitoring programs.

b) Land Use Monitoring: The project is using GIS to examine what level of land use tracking is needed to tie water quality changes to land use activities.

c) Effectiveness of BMPs: Modeling and monitoring by the project provide additional information about the nutrient reductions from various animal waste management practices.

Contributions in each of these areas are discussed in detail in the 1985 NWQEP RCWP-CM&E Report.

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1980-1991

3. Total Project Budget: (excludes water quality monitoring funds and farmers' contributions) $2,388,977

4. Cost Share Budget:
a. Funds Allocated: $1,682,144
b. Total Farmers' Contributions: $560,715 as of 1990

5. Water Quality Monitoring Budget: $1,576,000

6. Watershed Area: 33,344 acres

7. Project Area: 33,344 acres

8. Critical Area: 15,257 acres

9. Project Land Use:

Use	% project area
cropland	10.5
pasture/range	51.4
woodland	21.3
urban/roads	10.7
other	6.0

10. Animal Operations in Project Area:
a. Dairy: 9,310 a.u.
b. Beef: none reported
c. Swine: none reported

11. Water Resource Type: streams, St. Albans Bay

12. Water Uses and Impairments:

St. Albans Bay has been used heavily for recreation in the past. From 1960 to 1978, annual day use of St. Albans State Park declined from 27,456 to 3,458 users (ref. 1). Worsening eutrophic conditions in the bay were the cause of this decline. Boating, swimming and aesthetic enjoyment of the Bay are impaired by excessive macrophytes and algal growth.

13. Water Quality at Start of Project:

St. Albans Bay frequently had eutrophic conditions in summer.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 33 inches
b. USLE 'R' Factor: 100
c. Geologic Factors: Topography ranges from steep slopes in the eastern region of the project area to fairly level terrain in the western region near Lake Champlain. Soils of the eastern region are largely glacial tills.

15. Water Quality Monitoring Program:

a. Timeframe: 1980 - 1990
b. Sampling Scheme:
1. Location and Number of Monitoring Stations: 4 bay stations; 5 tributary stations.
2. Sampling Frequency: bi-weekly-bay; tributaries- storm and ambient
3. Sample Type (e.g. grab, automatic): bay-grab; tributaries-automatic
c. Pollutants Analyzed: TSS, VSS, TP, OP, Turbidity, FC, NO_3, NH_3, TKN
d. Flow Measurements: continuous
e. Other: biological monitoring

16. Critical Areas:

a. Criteria: Amount of manure, distance from watercourse, present manure management practices, manure spreading rates.
b. Application of criteria: The project appears to have applied criteria rigorously to cost share applications.

17. Best Management Practices:

a. General Scheme: Install waste storage systems, control barnyard runoff, spread manure at proper rates
b. Quantified Implementation goals: treat 11,443 acres and 64 dairies
c. Quantified Contracting/Implementation Achievements:

Location	% under contract	% implemented
project area	40	27
critical area	74	46
critical area farms	74	59
project area farms	63	39

d. Cost of BMPs: Installation costs of the two major types of manure storage systems (180 day storage) for a 48 cow herd are:

System	Total cost ($)	Per cow cost ($)
Earthen-pit	15,230	263
Above-ground	43,844	756

Of these costs, RCWP pays about 75%.

f. Effectiveness of BMPs: Barnyard cleanup is estimated to be about 85% effective in reducing phosphorus runoff.

18. Water Quality Changes:

Bay stations: Trend analysis indicates that turbidity, TP, TKN, and chl *a* concentrations have decreased in certain parts of the Bay since 1983.

There is some indication of a phosphorus concentration reduction in Jewett Brook. A field-level paired watershed experiment showed that significant reductions in phosphorus and nitrogen export from the Jewett Brook subwatershed can be accomplished by eliminating the practice of spreading manure in the winter.

19. Changes in Water Resource Use:

Recreational use of the bay could more than double if significant improvements in water quality are perceived. Use of shoreline properties will also increase as water quality improves.

20. Incentives:

a. Cost Share Rates: 75% for animal waste management
b. $ Limitations: 50,000 maximum
c. Assistance Programs: ACP funds are also being used

21. Economic Benefits:

a. On-farm: Farmer's net income is likely to improve with installation of manure management systems when cost-shared 75% by RCWP. For the typical 48 cow herd and 180 day storage the increase in pre-tax income ranges from $900 for an above-ground system to $2,000 for an earthen-pit system. In total, farmers' net income over 50 years is projected to be $800,000 higher (discounted to present value) as a result of RCWP. This benefit comes primarily from labor, fertilizer and tax savings which exceed a farmer's share of costs.
b. Off-farm: Improving water quality in St. Albans Bay to that found in Lake Champlain would produce the following benefits (total over 50 years, discounted):

Benefit	$ Million
Recreation enhancement (swimming and boating)	5.2
Property value increase around bay	1.3
Reduced bay weed treatment	minor
Total	6.5

Part of these benefits would be due to improvements in municipal wastewater treatment.

III. Lessons Learned

Agricultural nonpoint source control projects can be designed so that benefits associated with water quality improvement exceed the costs of the project, even when the cost of treatment is relatively high.

1. Even in expensive dairy waste management projects, a high level of farmer participation can be obtained if there is:
   a) 75% cost share rates;
   b) a full-time coordinator who promotes participation;
   c) a high level of community and landowners' awareness of the water quality problems; and
   d) substantial on-farm labor and fertilizer savings.
2. In project area with a history of over-application of nutrients, simply reducing nutrient application rate to meet crop uptake demand may not be sufficient to achieve nutrient loading reductions in the near term because of the large nutrient reservoir in the soil.

IV. Project Documents

1. An Application for Assistance for a Rural Clean Water Program - St. Albans Bay, Lake Carmi Watersheds, Vermont Agency of Environmental Conservation.

2. Rural Clean Water Program - St. Albans Bay Project Plan of Work. 1980.

3. Technical Manual for the SNR Water Resource Research Center (WRRC) - Computerized Data Management System (COMS)

4. Comprehensive Monitoring and Evaluation Plan for the St. Albans Bay, Vermont Rural Clean Water Program. February 1981. Vermont Rural Clean Water Coordinating Committee.

5. St. Albans Bay Watershed RCWP Project Comprehensive Monitoring & Evaluation. June - November 1981. Progress Report

6. Comprehensive Monitoring and Evaluation - Progress Report for 1981 - St. Albans Bay, Vermont, Rural Clean Water Program. January 1982. Vermont Rural Clean Water Coordinating Committee.

7. Socioeconomic Evaluation - St. Albans Bay, Vermont - Annual Report. 1982. C. Edwin Young.

8. St. Albans Bay Rural Clean Water Program - Annual Report. November 1982. U.S. Department of Agriculture, Vermont Water Resources Research Center.

9. St. Albans Bay Rural Clean Water Program - Annual Progress Report. 1983. U.S. Department of Agriculture, Vermont Water Resources Research Center.

10. St. Albans Bay Rural Clean Water Program - Summary Report. 1984. U.S. Department of Agriculture, Vermont Water Resources Research Center.

11. St. Albans Bay Watershed RCWP Project Comprehensive Monitoring and Evaluation - Progress Report. November 1984.

12. St. Albans Bay Watershed RCWP Project Comprehensive Monitoring and Evaluation - Progress Report. February 1985.

13. St. Albans Bay Rural Clean Water Program - Annual Progress Report. 1985. U.S. Department of Agriculture, Vermont Water Resources Research Center.

14. St. Albans Bay Watershed RCWP Project Comprehensive Monitoring and Evaluation - Progress Report. November 1985.

15. St. Albans Bay Watershed RCWP Project Comprehensive Monitoring and Evaluation - Progress Report. May 1986.

16. St. Albans Bay Rural Clean Water Program. Annual Progress Report. 1986.

17. Ribaudo, Mark O., C. E. Young and D. J. Epp. Recreation Benefits from Improvements in Water Quality at St. Albans Bay, Vermont. Staff Report no. AGES840127, Economic Research Services, U.S.D.A., March 1984.

18. Young, C. Edwin. "Perceived Water Quality and the Value of Seasonal Homes." Water Resources Bulletin, 20:153, April 1984.

19. Young, D. Edwin and Frank A. Teti. The Influence of Water Quality on the Value of Recreational Property Adjacent to St. Albans Bay, Vermont. Staff Report No. AGES831116, Economic Research Service, U.S.D.A., January 1984.

20. Frevert, Kathleen and Bradley Crowder. Analysis of Agricultural Nonpoint Pollution Control Options in the St. Albans Bay Watershed, Staff Report No. AGES870423. Economic Research Service, U.S.D.A., June 1987.

21. Ribaudo, Mark, C. Edwin Young, and James S. Shortle. Impacts of Water Quality Improvement on Site Visitation: A Probabilistic Modeling Approach. Water Resources Bulletin, Vol. 22. No. 4. August 1986. pp. 559-563.

V. NWQEP Project Contacts

Water Quality Monitoring
Dr. Jack Clausen
University of Vermont
Aiken Center
Burlington, VT 05405
Telephone(802) 656-4057

Economic Evaluation
C. Edwin Young
Economic Research Service/RTD
U.S. Dept. of Agriculture
1301 New York Ave. NW, Rm. 508
Washington, DC 20005-4788
tel. (202) 786-1401

Land Treatment/Technical Assistance
Jeff Mahood
USDA - Soil Conservation Service
69 Union Street
Winooski, VT 05404
Telephone (802) 655-9430

Information & Education
Bill Jokela
University of Vermont
Coop. Ext. Service
Aiken Center
Burlington, VT 05405
tel. (802) 656-4057

LOWER MANITOWOC RIVER WATERSHED - RCWP 13

Manitowoc, Brown, and Calumet Counties, Wisconsin
MLRA: L-95 A & B
H.U.C. 040301-01

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

Little information on the water quality effectiveness of BMPs will be determined by this project. Although implemented practices may improve water quality, monitoring is not designed to detect it.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:** 1980-1990

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): $ 1,867,026 (ref. 8, p. 17)

4. **Cost Share Budget:**
   a. Funds Allocated: $ 1,575,807
   b. Total Farmers' Contributions 1985: $1,027,200 estimation as of August 1985

5. **Water Quality Monitoring Budget:** $5,000

6. **Watershed Area:** 352,000 acres

7. **Project Area:** 102,000 acres (lower section of Manitowoc River Basin)

8. **Critical Area:** 23,598 acres

9. **Project Land Use** (ref. 4, p.8)

Use	% project area
cropland	67
woodland	28
urban/roads	5

10. **Animal Operations in Project Area:** (ref.4 pp. 8, 13, and 15)
    Dairy farming is the primary agricultural activity in the project area. There are 333 livestock operations with approximately 13,000 cows (13,000 a.u.) and an average of 39 cows per operation. There are 83 smaller herds with less than 20 milk cows and 250 larger herds with more than 20 milk cows.

11. **Water Resource Type:** A small lake, Manitowoc River, wetlands and streams, all draining to Lake Michigan.

12. **Water Uses and Impairments:**
    The nearshore waters of Lake Michigan are used for recreation (swimming, fishing and boating), shipping, and public water supply for the City of Manitowoc. These waters are impaired by algal growth due to the excessive quantities of phosphorus and by high bacteria levels. The harbor capacity is reduced by sedimentation which necessitates dredging to maintain shipping channels.

The river, streams and lakes within the project area are used primarily for fishing and other recreational activities. The lake is eutrophic as a result of excess phosphorus which impairs the fishery. The fishery in the river is also impaired by high phosphorus levels and high fecal coliform levels. Sedimentation of the riverbed is also a problem. Project area water resources are used by about 40,000 people in and adjacent to the watershed. This number does not include recreational visitors to the watershed.

13. Water Quality at Start of Project: (ref. 4, p.5)
Phosphorus Loadings Measured at the Mouth of the Manitowoc River

Year	Pounds of P Per Year[1]
1973	211,000
1974	196,000
1975	106,000
1976	103,000
1977	39,000
1978	182,000
Mean	139,500

[1]P loads are from multiple point and nonpoint sources. The estimated P load from livestock waste and cropland erosion from the project area is 55,080 pounds of P per year (ref.7 p.20).

14. Meteorologic and Hydrogeologic Factors:
a. Mean Annual Precipitation: ~29 inches
b. USLE'R' Factor: ~100
c. Geologic Factors: Topography varies from rolling to moderately steep. Soils are generally fine-textured with clay loams predominant. Precipitation does not readily infiltrate into these heavy soils and runoff is high.

15. Water Quality Monitoring Program:
a. Timeframe:
1. Mouth of river: 1973-1990 and could continue
2. Biological Monitoring: Mostly in the upper reaches and tributaries in the project area from 1979 to 1982. One site on a tributary will continue to be biologically monitored probably from 1985 to 1987.

b. Sampling Scheme:
1. Location and Number of Monitoring Stations:
Two water quality stations at the base of the project area are located above and within the City of Manitowoc. These stations are influenced, however, by the backwash of Lake Michigan, point sources, urban NPS, the RCWP project area, and areas upstream from the project.
Thirteen sites were biologically monitored, 4 are located on the lower Manitowoc River and 9 are located on tributaries to the river.
2. Sampling Frequency: (ref.4, p.22)
Mouth of river: In the zone of influence of urban sources and Lake Michigan) 1973-1979--monthly and high flow 1979-1982--biweekly, 1982-1990--monthly
Biological monitoring: Once in the fall and spring of 1979 and 1982. Fall and spring sampling of one site will continue from 1985 to 1987. The continuing site, however, was not selected to show impact of the project.
3. Sample Type:
Mouth of river: not reported, probably grab sample
Biological monitoring: sampling arthropods by grab samples with D-frame aquatic net

c. Pollutants Analyzed:
Mouth of river: suspended solids, VSS, TP, soluble P, dissolved silica, total lead, chloride, total zinc, total solids, conductivity, copper, cadmium, and nickel
d. Flow Measurements: only at mouth of river with automatic, continuous equipment
e. Other: The model CREAMS is being used to estimate potential farm-scale benefits of various practices. Comparable results of conventional vs. conservation practices have not yet been reported.

16. Critical Areas:

a. Criteria: 1. all lands within 1/8 mile of water course
2. lands with slopes 6% or greater that are 1/4 mile from water course
3. livestock operations have been categorized as follows:
i. need of barnyard runoff controls and manure storage--104 large operations
ii. need of manure storage--88 large operations
iii. small water quality impact--83 smaller operations
iiii. no impact on water quality--58 large operations

b. Application of Criteria: procedures well established and consistent

17. Best Management Practices:

a. General Scheme: Land treatment practices that deal with animal waste management and erosion control have been emphasized by the project. BMPs approved for the project include RCWP BMPs 1, 2, 3, 4, 5, 7, 9, 10, 11, and 12.

b. Quantified Implementation Goals: The project's treatment goals are to treat 75% of the critical areas (17,711 acres), including 122 dairies and 28 erosion sources other than livestock farms.

c. Quantified Contracting/Implementation Achievements as of September 1986 (ref. 8, p. 16)

Location	% under contract	% implemented
project area	13	7
critical area	57	31
critical area farms	40	NA
project area farms (animal operations only)	38	NA

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 Perm. veg. cover	35/ac.	35/ac.	70/ac.
2 Animal waste mgmt.	890-9,000 ea.	2,075-11,860 ea.	2,965-16,940 ea.
3 Stripcropping	7/ac.	16.40/ac.	23.40/ac.
4 Terracing	3/ft.	7/ft.	10/ft.
5 Diversions	0.47/ft.	1.10/ft.	1.57/ft.
7 Waterways	865/ac.	2,015/ac.	2,880/ac.
9 Contour Farming	2.40/ac.	5.60/ac.	8/ac
9 Conservation Till.	8.25/ac.	19.30/ac.	27.55/ac.
10 Stream Crossings	300 ea.	700 ea.	1,000 ea.
10 Fencing	0.27/ft.	0.62/ft.	0.89/ft.
11 Perm. veg. on crit. ac.	46/ac.	106/ac.	152/ac.
12 Sediment retention, erosion, water control	128 ea.	300 ea.	428 ea.

e. Effectiveness of BMPs: not reported

18. Water Quality Changes: not reported

19. Changes in Water Resource Use:

The city of Manitowoc continues to pump water from the harbor for domestic use. About 10 days per year high bacteria levels due to heavy rains preclude use of the harbor as a water supply and secondary rain collector wells are used as a water supply. The secondary wells need to be maintained as long as periods of high bacteria levels occur. There is no information indicating any change in recreational use. The average amount of material dredged from the harbor since RCWP began has been 25,000 cubic yards per year, compared to 41,400 cubic yards per year prior to RCWP. However, there has been a large amount of variation in dredging rates due to varying rainfall levels.

20. Incentives:

a. Cost Share Rates: BMPs 1 and 3 are cost shared at 50%; BMP 2, animal waste transfer components, are cost shared at 40%; all other BMP 2 components have 70% rate; BMPs 4, 5, 7, 9, 10, 11, and 12 have

70% rate.

b. $ Limitations: $50,000 per landowner

c. Assistance Programs: Within the project area a state cost sharing program is being used in conjunction with the RCWP project.

d. Other Incentives or Regulations: none reported

21. Potential Economic Benefits:

a. On-farm: not evaluated

b. Off-farm:

1) Recreation: 0
2) Water Supply: $40,000 per year.
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown
6) Downstream Impacts: unknown but positive

III. Lessons Learned

If a majority of the practices under contract are installed, there could be an improvement in water quality from reducing agricultural NPS in the project area. The biological monitoring was performed prior to substantial BMP implementation and the two monitoring sites at the base of the watershed reflect the influence of the total watershed including urban areas. Thus, the water quality monitoring design cannot adequately document the sources of contamination (i.e., incoming waters from the upper portion of the watershed, backwash from Lake Michigan, point sources, and urban and agricultural NPS) nor the cause of any potential water quality improvement. Thus, any water quality benefit from this project will not be documented.

IV. Project Documents

1. Lower Manitowoc River Watershed Application for RCWP, 1979. Manitowoc, Brown, and Calumet Counties, Wisconsin, 17pp.

2. The Lower Manitowoc River Priority Watershed Plan, 1979. Wisconsin. 50pp.

3. Lower Manitowoc River Watershed RCWP, (no date). 44 pp.

4. 1982 Annual Report of the Lower Manitowoc River Watershed RCWP, 1982. Wisconsin. 68 pp.

5. 1983 Annual Report of the Lower Manitowoc River Watershed RCWP, 1983. Wisconsin.

6. 1984 Annual Report of the Lower Manitowoc River Watershed RCWP, 1984. Wisconsin.

7. 1985 Annual Report of the Lower Manitowoc River Watershed RCWP, 1985. Wisconsin.

8. 1986 Annual Report of the Lower Manitowoc River Watershed RCWP, 1986. Wisconsin.

V. NWQEP Project Contacts

Water Quality Monitoring
Jim Baumann
Dept. of Natural Resources
P.O. Box 7921
Madison, WI 53707
tel. (608)266-9278

Land Treatment/Technical Assistance
Robert L. Wenzel, Chairman
Manitowoc County LCC
Route 2
Brillion, WI 54110

TAYLOR CREEK-NUBBIN SLOUGH BASIN -- RCWP 14

Okeechobee and Martin Counties, Florida
MLRA: U-156A
H.U.C. 030901-02

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The effectiveness of reducing phosphorus levels in Lake Okeechobee by preventing dairy cows from lounging in streams should be documented by this project. The combined effectiveness of stream protection, grazing land management, fertilizer management, and animal waste management on the subbasin and watershed scales should be measured as well.

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1981-1991

3. Total Project Budget (excludes water quality monitoring funds and farmers' contributions) : $1,534,202

4. Cost Share Budget:
a. Funds Allocated: $1,104,250
b. Total Farmers' Contributions: $272,157 as of 1985

5. Water Quality Monitoring Budget: $400,000

6. Watershed Area: 110,000 acres

7. Project Area: 110,000 acres

8. Critical Area: 63,109 acres

9. Project Land Use:

Use	% Project Area
cropland (mostly citrus groves)	2
pasture/range	
a. dairy	30
b. beef	45
woodland and wet prairies	18
urban/roads	5

10. Animal Operations in Project Area:
a. Dairy: 24 farms with average of 1167 cows (28,000 a.u.)
b. Beef: 56 cattle farms with average of 446 cattle (12,500 a.u.)
c. Swine: none
d. Poultry: none

11. Water Resource Type: streams, Lake Okeechobee

12. Water Uses and Impairments: (ref. 1,7, 9)

Lake Okeechobee is the source of public drinking water for five towns around the lake. It is also the secondary source of water supply for the lower east coast from West Palm Beach to Miami. A commercial fishery worth $6.3 million annually is supported by the lake. The lake's sport fishing industry is worth $22 million annually (ref. 9). In addition, a diverse wildlife habitat draws many tourists to the lake area.

The Taylor Creek-Nubbin Slough Basin contributes a disproportionate amount of phosphorus to Lake Okeechobee (~30% of P load in only ~4% of inflow to the lake). Use of lake waters is impaired by eutrophic conditions.

13. Water Quality at Start of Project:

1980 mean annual concentrations at station S-191, the outlet of project area (ref.1, p.19).

Pollutant	(mg/l)
TP	0.99
OP	0.88
TN	3.33
NO_3 NH_3 NO_2	1.01

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 50.0 inches

b. USLE 'R' Factor: ~400

c. Geologic Factors: Topography is relatively flat. Soils are coarse textured, mostly poorly drained with rapid permeability and medium drainage. An organic hard pan underlies much of the area with loam or marl under the rest, all of a depth of less than 50 inches. The water table is very shallow. Seasonal groundwater fluctuations are closely related to the seasonality of rainfall.

15. Water Quality Monitoring Program:

a. Timeframe: RCWP monitoring is from 1981 to 1991; some stations have been monitored for water quality since 1978. Discharge at 5 reaches has been monitored since early 1970's.

b. Sampling Scheme:

1. Location and Number of Monitoring Stations:
There are 23 instream grab stations within the project area. These do not include Lake Okeechobee, which is monitored by other programs.
2. Sampling Frequency: biweekly
3. Sample Type: grab samples, with instantaneous flow measurements starting May, 1983 for those stations that had not been monitoring discharge

c. Pollutants Analyzed: TP, OP, NO_3, NO_2, NH_3, TKN, pH, conductivity, turbidity, and color

d. Flow Measurements: Five stations have had flow monitored since the early 1970's. The other stations have had flow monitored since May, 1983.

e. Other: Precipitation and ground water levels have also been monitored within the project area.

16. Critical Areas:

a. Criteria: (1) all dairy farms in the project area, (2) beef cattle farms that have been extensively drained, and (3) areas within 1/4 mile of streams, ditches, and channels that hold water year-round

b. Application: Application of criteria is exceptionally strict, with graphic reports of the critical areas and contracted areas of the project on a subbasin scale. There appears to be little contracting of non-critical areas.

17. Best Management Practices:

a. General Scheme: The emphasis of BMP contracts is on grazing land management and protection, animal waste management, and stream protection (i.e., RCWP BMPs 1, 2, 6, and 10). Other BMPs include diversion systems and sediment retention (RCWP BMPs 5 and 12).

b. Quantified Implementation Goals: The project has achieved its two implementation goals: (1) contracting 75% of the critical area and (2) contracting all 24 dairy farms in the project area.

c. Quantified Contracting/Implementation Achievements: as of September 30, 1986. (ref.7, p.7-8)

Location	% under contract	% implemented
project area	50	69
critical area	87	78
critical area farms	82	not available
project area farms	83	not available

d. cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	State Share ($)	Total Cost ($)
2 animal waste mgmt.	51.35/ac.	45.75/ac.	13.60/ac.	110.70/ac.
5 diversions	6.80/ac.	1.40/ac.	16.70/ac.	24.90/ac.
6 grazing land prot.	2.65/ac.	8.20/ac.	1.70/ac.	12.55/ac.
10 stream prot.	7.20/ac.	28.50/ac.	9.80/ac.	45.50/ac.
12 sediment retention & erosion control struc.	9.80/ac.	31/ac.	8.20/ac.	49/ac.

e. Effectiveness of BMPs: The project has a study to document the effectiveness of removing cows from a stream. The results should be reported at a later date.

18. Water Quality Changes:

This project has had a high rate of BMP implementation with most of the implementation occurring in 1985 and 1986. This allows for a very nice pre-BMP water quality data base which can be quantified more accurately in the next few years. There is strong evidence, however, that two dairy closures in the Otter Creek subbasin (Sept. 1981 and 1985) had a possible impact on the phosphorus level in Otter Creek (Ref. 8). Mosquito Creek also shows a significant decrease in total phosphorus (Ref. 8).This subbasin has an intensive BMP implementation program. In contrast, in northwest Taylor Creek subbasin (in the upper part of the project area), increased animal densities have had a negative effect on water quality (Ref. 8).

There has been an overall decrease in total P concentration at station S191 (the main discharge to Lake Okeechobee from this watershed) (Ref. 8). It is postulated that this decrease is largely a function of the dairy closures in Otter Creek and the high number of BMPs installed in the Mosquito Creek subbasin. Fencing cows away from stream access, manure management, and fertilizer management are thought to be significant contributors to the decreased total P concentrations.

19. Changes in Water Resource Use:

Lake Okeechobee continues to be used for commercial fishing and as a primary water supply for approximately 27,000 people. Commercial fishing harvests have increased from 3.08 million pounds in 1981-1982 to 6.26 million pounds in 1984-1985. Water for domestic use continues to need treatment for algae related problems. No recreational fishing use data is available to indicate user trends. However, recreational fish harvests have increased from 660,300 fish in 1981-1982 to 1,248,100 fish in 1984-1985. Most of the variation in recreational fishing appears to be the result of low water levels in the early 1980's.

20. Incentives:

a. Cost Share Rates: 75% for structural BMPs
b. $ Limitations: $50,000 per landowner
c. Assistance Programs: include supplemental state funds for cost sharing BMPs in some parts of the basin
d. Other Incentives or Regulations: The landowners have two incentives for implementing BMPs during this project period: cost-sharing is available for structural BMPs and technical assistance is available for all contracted BMPs. Another incentive for installing the non-structural BMPs is the threat of a permit system that could require these BMPs at a later date when the technical assistance is not available.

21. Potential Economic Benefits:

a. On-farm: not evaluated

b. Off-farm:

1) Recreation: 0 - $1,800,000 per year.
2) Water Supply: $80,000 per year.
3) Commercial Fishing: $250,000 - $1,000,000 per year.
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: 0

III. Lessons Learned

This project has used two tactics to attract farmer participation: the threat of regulation and the incentive of higher cost share rates in some subbasins (with supplemental state funds). These methods appear to have been successful in that the project has exceeded its contracting goal. This project could demonstrate how a large project can be successful.

In a large project area with several impaired water uses the off-farm benefits are potentially very high. When combined with low cost land treatment, positive out benefits from nonpoint source control are possible.

IV. Project Documents

1. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1981. Project Plan of Work. Okeechobee County, FL.

2. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1982. Annual Progress Report. Okeechobee County, FL.

3. Ritter, G.J. and L.H. Allen, Jr., 1982. Taylor Creek Headwaters Project Phase I Report; Water Quality. South Florida Water Management District, West Palm Beach, FL.

4. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1983. Annual Progress Report. Okeechobee County, FL.

5. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1984. Annual Progress Report. Okeechobee County, FL.

6. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1985. Annual Progress Report. Okeechobee County, FL.

7. Taylor Creek-Nubbin Slough RCWP No. 14, November, 1986. Annual Progress Report. Okeechobee County, FL.

8. Ritter, G.J. and E.G. Flaig. 1987. Technical Memorandum: 1986 Annual Report, Rural Clean Water Program. South Florida Water Management District, Department of Resource Planning - Water Quality Division.

9. Bell, F.W. 1987. Economic Impact and Valuation of the Recreational and Commercial Fishing Industries of Lake Okeechobee, Florida. Department of Economics, Florida State University, Tallahassee, Florida.

V. NWQEP Project Contacts

Water Quality Monitoring

Gary Ritter
South Florida Water Management District
P.O. Box 938
Okeechobee, FL 34973
tel. (813) 763-3776

and

Eric Flaig
South Florida Water Management District
P.O. Box 24680
3301 Gun Club Rd.
West Palm Beach, FL 33416-4680
tel. (407) 686-8800

Information and Education

Vickie Hoge
CES
501 N.W. Fifth Ave.
Okeechobee, FL 34972
tel. (813) 763-6469

Land Treatment/Technical Assistance

Lorin Boggs
USDA - SCS
611 S.W. Park St.
Okeechobee, FL 34972
tel. (813) 763-3617

and

Jack Stanley
USDA - ASCS
609 S. W. Park Street
Okeechobee, FL 34972
tel. (813) 763-3345

WESTPORT RIVER WATERSHED - RCWP 15

Bristol County, Massachusetts
MLRA: R-145
H.U.C. 010900-04

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project will make little contribution because it has a low level of implementation.

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1981-1991

3. Total Project Budget (includes funds for technical assistance, cost sharing, and information and education, but excludes water quality monitoring funds and farmers' contributions): $ 656,643 (1986 Project Progress Report, RCWP-5)

4. Cost Share Budget:
a. Funds Allocated: $ 518,401 (1986 Project Progress Report, RCWP-5)
b. Total Farmers' Contributions: $172,799 (1986 Project Progress Report, RCWP-7)

5. Water Quality Monitoring Budget: $0

6. Watershed Area: 47,000 acres

7. Project Area: 47,000 acres (approximately one third of project area is not monitored). Part of project area is in Rhode Island.

8. Critical Area: 473 acres on East Branch of Westport River

9. Project Land Use (equivalent to watershed land use): (ref. 4, pp. 21,22)

Use	% project area
cropland	3
pasture/range	10
woodland	80
urban/roads	
other	7

10. Animal Operations in Project Area: (ref. 5, p. 10 & ref. 4, p. 22, except as noted):
a. Dairy: 14 farms with average 159.3 cows (2230 a.u. - ref. 7, p. 3)
b. Beef: 5 cattle farms with average of 60 cattle (270 a.u.)
c. Swine: 12 farms with average of 83 pigs/hogs (175 a.u.)
d. Poultry: 1 farm with average of 60,000 chickens, etc. (270 a.u.)
e. Sheep: 1 farm with average of 100 sheep (50 a.u.)
f. Horse: 3 farms with average of 50 horses (110 a.u. - ref. 6, p. 10)

Animal operations in critical area
a. Dairy: 8 farms (ref. 7, p.5)
b. Beef: 7 farms (ref. 6, p.10)

c. Swine: 6 farms (ref. 6, p.10)
d. Poultry: 1 farm (ref. 6, p.10)
e. Horse: 3 farms (ref. 6, p.10)

11. Water Resource Type:

There are wetlands and lakes in the upper section of the watershed which drain into the West Branch of the Westport River. Both the East and West Branches of the river discharge into an estuary.

12. Water Uses and Impairments:

Ponds in the project area are used for recreation (limited to local residents) and for municipal water supply. The Westport River supports commercial shellfishing (average of $425,000 annually from 1980-1984, $2,671,000 in 1985 due to extremely high scallop harvest), and public recreation. The main use impairment is the closure of shellfishing beds in the estuary due to bacterial contamination. Other reported impaired uses include boating, contact recreation, and fishery.

13. Water Quality at Start of Project: 1979 Coliform Bacteria Data for Station 6 at Hix Bridge, the impaired tidal area: (ref. 4, p.36, ref. 6, pp. 34-36)

	FC(*)	TC(**)	n
log mean (#/100ml)	62	103	7
median (#/100ml)	36	91	7
% exceedance 43/100 ml	28	---	7
% exceedance 23/100 ml	---	43	7

* U.S.EPA recommendations for shellfishing waters includes: a) median FC value should not exceed a MPN of 14 per 100 ml and b) not more than 10% of the samples should exceed an MPN of 43 (Quality Criteria for Water, 1976).

** MA Water Quality Standards for shellfishing waters includes: a) median TC shall not exceed 70 MPN per 100 ml and b) not more than 10% of the samples shall exceed 230 MPN per 100 ml.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 39.8 inches
b. USLE 'R' Factor: ~150
c. Geologic Factors: The project is located in the central lowland section of the New England Physiographic Province. Topography is gently rolling. Soils are loamy and moderately to well drained. Substrata are compact and permeability is slow. The surface drainage pattern is a series of wetland areas connected by a system of streams and the river.

15. Water Quality Monitoring Program:

a. Timeframe: 1982-1990
b. Sampling Scheme:
1. Location and Number of Monitoring Stations: 10 sampling stations, 9 of which are along the fresh water tributaries and streams and one is located in the tidal estuary.
2. Sampling Frequency: approximately 6 to 10 times per year
3. Sample Type: It appears that all stations except site 5 are monitored by grab samples. Site 5 has an automatic sampler but grab samples are taken for bacterial analysis.

c. Pollutants Analyzed: temperature, pH, DO, TC, FC, FS, Chloride, TSS, TDS, NO_3, NO_2, TKN, TP, DP, conductivity, and alkalinity.
d. Flow Measurements: For freshwater stream stations, the stage is to be measured and converted to flow after hydraulic analysis is completed. None of these values (stage or flow) has yet been reported by the project.

16. Critical Areas:

a. Criteria: The critical area was redefined to focus on dairy farms, which are the sources of bacterial contamination. 8 dairy farms are in the critical area.
b. Application of Criteria: Practices are being implemented outside the critical area. Participation within

the critical area is poor. Cultural barriers between project personnel and most dairy farmers, the USDA Dairy Buy-Out program, and uncertainty in the dairy industry are factors in this project.

17. Best Management Practices:

a. General Scheme: RCWP BMPs approved for this project are 1-12, 15, and 16. The main focus, however, is on animal waste management.
b. Quantified Implementation Goals: To contract with all 8 dairies in critical area, and to treat all agricultural land within the critical area. Four farms in the critical area have contracts.
c. Quantified Contracting/Implementation Achievements: As of Sept. 30, 1986 (ref. 7, p. 6,13)

Location	% under contract	% implemented
project area	NA	2
critical area	NA	23
critical area dairies	50	NA
(crit. area dairies are sources of the bacterial contamination)		
project area dairies	36	NA

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	124/ac.	115/ac.	239/ac.
2 animal waste mgmt.	18,200 ea.	23,900 ea.	42,100 ea.
4 terraces	2.87/ac.	7.80/ac.	10.67/ac.
7 waterways	0.56/ac.	1.70/ac.	2.26/ac.

e. Effectiveness of BMPs: not reported to date

18. Water Quality Changes: no improvements have been reported

19. Changes in Water Resource Use:

Shellfish bed closures have continued in the Westport River area. The number of closed areas have increased due to continued high bacteria levels, with the greatest impact on oyster production. Commercial oyster harvests have decreased from 340 bushels in 1980 to 85 bushels in 1985. Harvests of other shellfish have generally increased during the same time period despite high bacteria levels. The amount of recreational shellfishing appears to be relatively steady, with 959 permits issued in 1985 compared to 814 permits in 1981.

20. Incentives:

a. Cost share rates: 75%
b. $ Limitations: $50,000 per landowner
c. Assistance Programs: None have been reported as part of the RCWP project other than I&E and technical assistance. ACP funds have been used to establish cover crops within the watershed.

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
1) Recreation: 0
2) Water Supply 0
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown
6) Downstream Impacts: 0

III. Lessons Learned

Criteria for selecting critical areas were not well established at the beginning of the project and did not focus on the main cause of impairment. However, in 1986 the project redefined the critical area, focusing on dairy runoff. Although an adequate water quality monitoring design was employed, it will do little good if sufficient and appropriate BMP implementation is not achieved.

There is a jurisdictional problem on the Rhode Island state boundary concerning who should address bacterial contamination which has recently appeared downstream in the West Branch of the Westport River in Massachusetts. There is also a communication problem concerning project activities because of cultural differences between project personnel and Portuguese dairy owners within the project area.

IV. Project Documents

1. Rose, D. and P. Fisher (ASCS), 1981. Westport River Watershed Application for USDA - RCWP Special Project. Bristol County, MA 47 pp.

2. Westport River RCWP Project Local Coordinating Committee, 1981. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 50 pp.

3. Westport River RCWP Project Local Coordinating Committee, 1982. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 26 pp.

4. Westport River RCWP Project Local Coordinating Committee, 1983. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 108 pp.

5. Westport River RCWP Project Local Coordinating Committee, 1984. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 42 pp.

6. Westport River RCWP Project Local Coordinating Committee, 1985. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 51 pp.

7. Westport River RCWP Project Local Coordinating Committee, 1986. RCWP Westport River Watershed Project Plan of Work and Annual Progress Report. Westport, MA 15 pp.

V. NWQEP Project Contacts

Land Treatment/Technical Assistance

Joanne Haracz
District Conservationist
SCS
21 Spring St.
Taunton, MA 02780
tel. (617) 824-6668

Water Quality Monitoring

Larry Gil
Div. of Environmental Quality Eng.
Water Pollution Control
Westboro Technical Services Branch
Lyman School
Westboro, MA 02790
tel. (617) 727-0437

GARVIN BROOK - RCWP 16

Winona County, Minnesota
MLRA: M-105
H.U.C.: 070400-03

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project has demonstrated the use of a computer model to identify and evaluate of critical areas for surface water problems. Critical areas for ground water problems were identified by extensive geologic mapping and locating sinkholes and abandoned wells through which pollutants can easily enter the ground water.

The project demonstrates the effectiveness of nutrient management based on a nitrogen budget utilizing data on crop yields, commercial fertilizer use, retention of N in soils, and animal waste application. This is important to illustrate to farmers the value of animal waste as a nutrient resource.

II. Project's Characteristics and Results

Background: The project's original objective was to treat nonpoint sources of pollutants entering Garvin Brook, a high quality trout stream. In 1985, after three years of work within the original surface watershed area, the project shifted its emphasis to ground water quality. The change was made after analysis of samples from 80 wells within the surface watershed showed that 21% of the wells had levels of NO_3-N exceeding the 10 mg/l drinking water standard. In 1985, the Garvin Brook RCWP expanded its project area to include all of the ground water watershed (approximately one-half is outside the surface watershed). While the full range of BMPs was approved for cost share funding on the original project area, funding was restricted to BMPs 15 and 16 in the expanded area. Critical areas were redefined and the total number needing treatment increased.

1. Project Type: RCWP

2.Timeframe: 1982-1991

3. Total Project Budget: (excludes water quality monitoring and farmer's contributions) $1,809,662

4. Cost Share Budget:
a. Funds Allocated: $1,077,022
b. Total Farmers' Contributions: $242,246
c. Winona County funds: $118,000

5. Water Quality Monitoring Budget: $270,500
$120,500 original monitoring budget
$150,000 for ground water monitoring (1987-1989)

6. Watershed Area: 46,516 acres (30,720 acres original surface watershed plus 15,796 acres in the expanded ground water watershed)

7. Project Area: 46,516 acres

8. Critical Area: 20,255 acres (12,681 acres affect ground water quality and 7,574 affect surface water quality)
Of the 20,255 acre critical area, 10,714 are listed as needing treatment (7,609 for ground water and 3,105 acres for surface water protection). All acres needing treatment are in annual row crop production.

9. Project Land Use:

Use	% original area	% expanded area	% project area
pasture/range	12	~5	~10
woodland	25	~5	~18
urban/roads	2	5	3
other (roads)	3	--	2

There are 218 farms, mostly small dairies, in the project area. There are 94 farms in the critical area. Dairy and cash grain are the primary farm operations.

10. Animal Operations in Project Area:

Original area (ref. 7):
a. Dairy: 54 farms with average of 94 cows (5,100 a.u.)(ref. 8)
b. Beef: 9 farms with average of 170 cattle (1,300 a.u.)
c. Swine: 13 farms with average of 335 pigs/hogs (880 a.u.)
e. Other: 8 miscellaneous farms (85 a.u.)
Expanded area (ref. 8):
a. Dairy: 8 farms with average of 283 cows (2,265 a.u.)

11. Water Resource Type: streams and ground water

Garvin Brook is designated a trout stream by the Minnesota Department of Natural Resources. The Prairie du Chien-Jordan aquifer is the impaired ground water resource.

12. Water Use and Impairments:

Current project area population is estimated at 2,500; most rely on domestic wells for water supply. Approximately 25,000 people use Garvin Brook for recreation, primarily swimming and fishing.

The primary ground water impairment is decreased drinking water quality from high nitrate concentration and pesticide contamination. Use of Garvin Brook for trout fishing is reportedly impaired, however, fishing impairments are not well documented. The primary pollutants in Garvin Brook are bacteria, sediment, and turbidity. Pollutant sources include nitrogen fertilizers, animal operations (mostly dairy), and pesticides.

13. Water Quality at Start of Project:

Garvin Brook: Turbidity levels exceeded standards (10 and 25 FTUs) 18-61 percent of the time. The FC standard (200 counts per 100 ml) was also violated 45-89 percent of the time.
Ground water: Of the 80 wells in the original project area tested in 1983 and 1984, about 21% had nitrate-N levels exceeding the drinking water standard of 10 mg/l. During the summer of 1985, 64 additional wells in the expanded ground water watershed were tested for NO_3-N. Forty-eight percent of these wells had NO_3-N levels exceeding the 10 mg/l standard. Measurable amounts of Alachlor and/or Atrazine were found in 6 of 10 wells tested. Levels were below health advisory level.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 33 inches (75 % occurs April-Sept.)
b. USLE 'R' Factor: 160
c. Geologic Factors: The watershed is characterized by karst topography. The bedrock is near-surface fractured and cavernous Dolomitic limestone and Paleozoic sandstone with sinkhole development. Sinkholes and rock fissures are direct channels for contaminated agricultural runoff to gain access to the Prairie du Chien aquifer.

15. Water Quality Monitoring Program:

a. Timeframe: surface water monitoring 1981-1985 and 1990; ground water monitoring 1981-1990
b. Sampling Scheme: In FY1986, the monitoring program shifted its emphasis from surface water to focus on ground water. Available funding was used predominantly for nitrate and pesticide monitoring of private farm water supplies. The expanded ground water monitoring effort is intended to track the effects of BMPs 15 and 16.

1. Location and Number of Monitoring Stations: The current program emphasis is on monitoring the original 80 well sites and 3 springs for nitrate in the surface water area and an additional 50 wells for nitrate and pesticide (alachlor and atrazine) in the ground water area. Monitoring of 196 private water supplies, including the above 50 wells, was reported in FY1986.
2. Sampling Frequency: ground water--yearly (May or June)
3. Sample Type: automatic

c. Pollutants Analyzed: ground water -- nitrates and pesticides (alachlor and atrazine) conductivity, pH and Cl

16. Critical Areas:

a. Criteria: The Agricultural Non-point Source Pollution Model I (AGNPS I) computer simulation model, which predicts runoff rate and volume, eroded and delivered sediment, total nitrogen, total phosphorus, and chemical oxygen demand was used to evaluate the surface watershed and designate priority areas. Critical area affecting ground water was determined by identifying excessive nitrogen and herbicide application areas and the location of sinkholes and abandoned wells.

b. Application of Criteria: Critical areas were substantially redefined in 1985 using new information about the ground water problems both within and outside of the original surface watershed project area. Redefinition of critical areas has resulted in expansion of critical acres needing treatment. These acres are now defined to be the cropland acres annually planted to row crops within the critical area and any sinkholes and abandoned wells. Only 1,423 acres reported as treated in the previously defined critical area meet the new definition of acres needing treatment. Animal units are known to be significant contributors to the pollution problem. However, animal waste systems were not accepted by farmers due to depressed economic conditions in the project area.

17. Best Management Practices:

a. General Scheme: BMPs 2,3,4,5,9,10,15,16 are considered important. This project has increased its emphasis on BMPs 15 and 16, including split nitrogen application, improved manure storage and improved calibration of manure and fertilizer spreading equipment.

b. Quantified Implementation Goals:

treat 8,095 of 10,793 critical acres (75%)
treat 33 of 44 dairies
fill 59 of 79 sinkholes
split N application on 8,036 of 10,714 acres
pesticide management on 15,169 of 20,255 acres
obtain 94 contracts

c. Quantified Contracting/Implementation Achievements:

The project has not reported the location of BMP activities with respect to critical areas. Quantified achievements are as follows:

9 sinkholes filled
7,590 acres treated with split N application
14,812 acres treated with pesticide management
69 RCWP contracts

d. cost of BMPs: (from RCWP 4 table, ref. 12)

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	55/ac.	175/ac.	230/ac.
2 animal waste mgmt	13,150 ea.	39,350 ea.	52,500 ea.
3 stripcropping	4.80/ac.	14.50/ac.	19.30/ac.
5 diversions	0.55/ft.	1.70/ft.	2.25/ft.
6 grazing land prot.	0.35/ft.	1.05/ft.	1.40/ft.
9 conservation tillage	375/ac.	1,125/ac.	1,500/ac.
10 stream protection	3.75/ac.	11.25/ac.	15/ac.
12 sediment retention, erosion control struc.	1,875/ac.	5,625/ac.	7,500/ac.

(continued on next page)

14 tree planting	3,425 ea.	10,275 ea.	13,700 ea.
15 fertilizer mgmt.	50/ac.	150/ac.	200/ac.
16 pesticide mgmt.	5/ac.	15/ac.	20/ac.

e. Effectiveness of BMPs: Under BMP 15 (split N application), the amount of total N applied that was applied early (fall or early spring) decreased from 64% for the 1985 growing season to 59% for the 1986 growing season (ref. 12). There was also a 20% reduction in the total N applied by farmers using split application for the 1986 growing season.
Effectiveness of BMPs for controlling sediment, phosphorus, nitrogen, and COD reduction in the project area is being evaluated by AGNPS I. The model is also being used to illustrate how livestock producers, many of whom grow corn, would benefit by managing their manure as a fertilizer resource.

18. Water Quality Changes:

No trends in surface water quality are reported by the project. The project does not intend to evaluate surface water quality trends until 1990. The expected effects of land treatment on surface water quality are currently being modeled with AGNPS I. There is evidence of increasing NO_3-N levels over four years of ground water data collected from the 80 original wells in the surface water watershed from 1983 to 1986.

19. Changes in Water Resource Use:

Population growth in Winona County is slow, 2.1% from 1980 to 1984, therefore, ground water use has probably changed little since RCWP began. Garvin Brook outlets to Pool 5A of the Upper Mississippi River. Total recreational use of Pool 5A is about 159,000 users annually. However, the contribution of sediment to Pool 5A from Garvin Brook is very small. Fishing use of the project area does not appear to have changed since RCWP began.

20. Incentives:

a. Cost Share Rates: 90 percent (75 percent from RCWP and 15 percent from the Winona County Board of Commissions)
b. $ Limitations: $50,000 RCWP funds plus $6,000 from Winona County per contract
c. Assistance programs: Extension service did nitrogen budgets for BMP-15 and included the use of legumes and manure; public meetings; newsletter; split-N application demonstration farm; crop scouting; free soil testing.

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
1) Recreation: 0
2) Water supply: $35,000 - $130,000 per year
3) Commercial fishing: 0
4) Wildlife habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream impacts: unknown but positive

III. Lessons Learned

Expensive structural BMPs (e.g. BMP-2) are difficult to sell in times of depressed economic conditions even with cost sharing as high as 90%. Lower cost manure management alternatives should have been promoted from the beginning of the project.

Critical area for treatment of surface water may differ from ground water critical area.

Development of nitrogen budgets for farmers' fields (accounting for N from manure and legumes) not only keeps excess quantities of commercial fertilizer from being available for leaching, but also allows the farmer to optimize the use of N from manure and legumes.

Off-farm benefits from improving or maintaining ground water quality are potentially large.

IV. Project Documents

1. Garvin Brook Rural Clean Water Project Application. 12 p.

2. Minnesota Soil and Water Conservation Board. March 1982. Minnesota's Soil and Water Conservation Program: A Process of Gaining Ground. Box 19, Centennial Office Building, St. Paul, Minnesota 55155. 56 p.

3. Balaban, N.H. and B.M. Olsen. 1984. Geologic Atlas Winona County, Minnesota. County Atlas Series Atlas C-2. Minnesota Geological Survey. University of Minnesota, St. Paul.

4. Annual Progress Report: Garvin Brook Rural Clean Water Project, Winona County, Minnesota. November 1982.

5. Annual Progress Report: Garvin Brook Rural Clean Water Project, Winona County, Minnesota. November 1982.

6. Payne, G.A.1983. Streamflow and Suspended-Sediment Transport in Garvin Brook, Winona County, Southeastern Minnesota--Hydrologic Data for 1982. U.S. Geological Survey. Open-File Report 83-212. St. Paul, Minnesota. 22p.

7. Annual Progress Report: Garvin Brook Rural Clean Water Project, Winona County, Minnesota. December, 1984. 20 p.
   Appendix A. Agreement Between the Agricultural Stabilization and Conservation Service and the Minnesota Pollution Control Agency.
   Appendix B. Garvin Brook Watershed Water Quality: General Monitoring for the Rural Clean Water Program. 1984 Annual Report. Minnesota Pollution Control Agency.
   Appendix C. RCWP Garvin Brook Project Technical Report Update. September, 1984. 29 p.
   Appendix D. BMP - Fertilizer Management - Split Application.
   Appendix E. Forms: ACP-305, RCWP-3, RCWP-5, RCWP-7, Contract locations.
   Appendix F. Questionnaire
   Appendix G. Summary of Trout Stream Habitat Improvement. 2 p.
   Appendix H. Project Coordinator - Position Description. 1 p.

8. Annual Progress Report: Garvin Brook Rural Clean Water Project PN16, Winona County, Minnesota. November 1985.

9. Garvin Brook Watershed Detailed Action Plan. April 1985. 4 p.

10. Supplement to Plan of Work. April 1985. 3 p.

11. Method Used to Determine Nitrate Loading. April 1985. 2 p.

12. Annual Progress Report: Garvin Brook Rural Clean Water Project PN16, Winona County, Minnesota. November 1986.

V. NWQEP Project Contacts:

Water Quality Monitoring
David Wall
520 Lafayette Road
Minnesota Pollution Control Agency
St. Paul, Minnesota 55155
Telephone (612) 296-7360

Land Treatment/Technical Assistance
Mark Kunz
USDA - SCS
Box 38
Lewiston, Minnesota 55952
Telephone (507)523-2171

LONG PINE CREEK - RCWP17

Brown and Rock Counties, Nebraska
MLRA: G-66
H.U.C. 101500-04

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The Nebraska RCWP combines an approach to both ground water and surface water problems. This project has potential to demonstrate effects of nutrient and pesticide management, irrigation water management as BMPs for surface and ground water quality protection.

II. Project's Characteristics and Results

1. Project Type: RCWP

2.Timeframe:1981-1995

3. Total Project Budget: (excluding monitoring and farmers' contributions) $2,233,231 (RCWP-5, ref. 13) If the secondary RCWP-5 is approved, $4,297,075 would be budgeted. This would include additional large sediment control structures.

4. Cost Share Budget: (ref. 13)
a. Funds Allocated: $1,386,975 ($3,317,475 if secondary RCWP-5 approved)
b. Total Farmers' Contributions: $394,825 (as of 1995) ($414,325 if secondary RCWP-5 approved)

5. Water Quality Monitoring Budget: $297,850

6. Watershed Area: 293,100 acres

7. Project Area: 80,000 acres

8. Critical Area: 54,212 acres

9. Project Land Use:

use	% critical area
cropland	25
- irrigated corn	(23)
- irrigated alfalfa	(2)
pasture/range	70
woodland	0
urban/roads	1
other	4

There are 130 farm or ranch units in the project area. Approximately 90 are thought to be critical.

10. Animal Operations in Project Area:
a. Dairy: 4 farms with 50 cows ave. (200 a.u.)
b. Beef: 11 farms with 2500 cattle (23,375 a.u.)
c. Swine: 1 farm with 500 pigs/hogs (100 a.u.)

11. Water Resource Type: surface streams and ground water
Surface water: Long Pine Creek (drainage = 293,100 acres, average aggregate flow = 150 cfs at mouth); major tributaries are Bone Creek, Sand Draw, and Willow Creek.

12. Water Use and Impairments:
Surface water: The Long Pine Creek Recreation Area, a state park, is used by over 8,500 people each season. The primary water use impairments are to recreation and fishing. Long Pine Creek is the longest self-sustaining trout stream in the state. Relic populations of three species of fish, threatened in Nebraska, can be found in the streams in this area. The primary pollutants are: sediment, bacteria, and nutrients. Streambank erosion is the primary source of sediment. This is exacerbated by peak flow events and excessive irrigation water imported from the basins. A secondary factor contributing to the streambank erosion is overgrazing. The other primary pollutants, bacteria and nutrients, are from feedlot storm runoff and agricultural fertilizers.
Ground water: Ground water is used for irrigation, stock watering and domestic and municipal water supply throughout the project area. A stable population of about 3,200 people live within the project area. There is potential for degradation of the drinking water supply from high nitrate and pesticide contamination.

13. Water Quality at Start of Project:
See Reference #15 for a complete baseline documentation (1979-1985). Suspended solids data from 9 sample dates from July, 1979 to July, 1980 show that two tributaries, Bone Creek and Sand Draw, contributed greatly to the turbidity problems in Lower Pine Creek (LP8). Station LP7 is located upstream of the confluence of Sand Draw and Bone Creek with Long Pine Creek. Station LP8 is below this confluence. Total suspended solids (TSS) at LP8 were fairly high, but were less at up stream LP1, LP5, or LP7.

Surface monitoring, April, 1980 to September 23, 1981 (n = ~13):

	Tot. Sus. Solids (mg/l)		Fecal Coliform (#/100ml)
Station*	Mean	Range	Geometric Mean
Long Pine (LP1)	13	1-32	315
Long Pine (LP5)	11	1-40	35
Long Pine (LP7)	20	1-50	90
Long Pine (LP8)	70	9-220	400
Bone Creek (BN)	1	1-1	670
Bone Creek (BN1)	95	1-620	4550
Bone Creek (BN2)	330	1-3590	1680
Bone Creek(BN3)	640	1-4360	1180
Sand Draw (SN1)	10	1-30	410
Sand Draw (SN2)	130	1-1000	500

*LP1, LP5, and LP7 are above confluences with tributaries. LP8 is below confluences.

b. Ground water: 23 domestic wells monitored in 1977-1978 show that 17 percent exceeded 10 mg/l nitrate-N

14. Meteorologic and Hydrogeologic Factors:
a. Mean Annual Precipitation: 21.5 inches; about 14.5 inches of irrigation water are needed to supplement precipitation to grow corn
b. USLE 'R' Factor: 100
c. Geologic Factors: The watershed is underlain by shale and sand stone. Topography is diverse, ranging from nearly level to steep. Most of the watershed is covered by a blanket of eolian sand material. Soils in the range area are predominantly silts and sands.

15. Water Quality Monitoring Program:
a. Timeframe: surface -- July 1979 - September 1984 - 1995 groundwater -- 1979 - 1995
b. Sampling Scheme:

1. Location and Number of Monitoring Stations: Baseline surface monitoring at 11 sites was collected from July 1979 to September 1984. This is considered the pre-implementation phase. Except for station LP8 (which will be sampled once per month after September 1984), surface water monitoring has been discontinued until the last two years of the project (1994-1995). Fish were collected between April 1981 and June 1984.

Irrigation and domestic wells are sampled once per year in July or August (when the aquifer is used for irrigation).

2. Sampling Frequency: Surface water: monthly for baseline samples, composite samples during runoff events, fish were collected 2-3 times per year. Ground water: Once per year in July or August (1982-1985)

3. Sample Type: grab

c. Pollutants Analyzed: (1) Surface water: all 11 sites are sampled for TSS, FC, DO, and conductivity. Seven of the sites include macroinvertebrate and periphyton sampling. Diurnal water temperatures are also recorded. (2) Ground water: Nitrate-N and pesticides.

d. Flow Measurements: Runoff event data is collected at six surface sites. Stream discharge is recorded.

16. Critical Areas:

a. Criteria: high erosion rates and proximity to waterways

b. Application of Criteria: consistent -- Contracts are primarily being applied to the critical areas.

17. Best Management Practices:

a. General Scheme:

Focus is on sediment control structures to trap sediment and control stream flow (BMP-12). The project is currently emphasizing on-site components such as irrigation water management (BMP-13). One major emphasis for this BMP is to install irrigation tailwater recovery (re-use) systems to minimize the total water usage, thereby reducing infiltration to ground water with ultimate release in the creek. A secondary storage reservoir (BMP-13) is being constructed using pooled funds from 10 RCWP cooperators within the Ainsworth irrigation district and is scheduled for completion in fall 1987. The reservoir will save 2,000 acre feet of water annually for 8,000 acres of cropland and reduce the amount of irrigation waste water delivered to the creeks with an associated reduction in sediment delivered. Other BMPs include fertilizer and pesticide management (BMP-15, BMP-16), diversion systems (BMP- 5), grazing land protection systems (BMP-6), stream protection (BMP-10), permanent vegetative cover on critical acres (BMP-11), Permanent vegetative cover (BMP-1), waterway system (BMP-7), Cropland protective system (BMP-8), conservation tillage (BMP-9), and tree planting (BMP-14).

b. Quantified Implementation Goals: 75 percent of the critical area

c. Quantified Contracting/Implementation Achievements:

Location	% under contract (end FY86)	% implemented
project area	53	not reported
critical area	78	not reported
critical area farms	94	not reported
project area farms	85	not reported

d. Cost of BMPs: (from RCWP Table 4, Ref. 16)

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 perm. veg. cover	20/ac.	60/ac.	80/ac.
2 animal waste mgmt.	3,750 ea.	11,250 ea.	15,000 ea.
5 diversions	0.30/ft.	1/ft.	1.30/ft.
6 grazing land prot.	0.75/ac.	2.25/ac.	1.50/ft.
7 waterways	0.30/ft.	1/ft.	1.30/ft.
8 cropland prot.	5/ac.	0	5/ac.
9 conservation till.	3.25/ac.	9.75/ac.	13/ac.
10 stream protection	0.40/ft.	1.10/ft.	1.50/ft.
11 perm. veg. on crit. area	125/ac.	375/ac.	500/ac.
12 sediment retention	300 ea.	900 ea.	1,200 ea.

13 irrigation/water mgmt.	2,500 ea.	7,500 ea.	10,000 ea.
14 tree planting	75/ac.	225/ac.	300/ac.
15 fertilizer mgmt.	0.33/ac.	1/ac.	1.33/ac.
16 pesticide mgmt.	0.33/ac.	1/ac.	1.33/ac.

e. Effectiveness of BMPs: not documented

18. Water Quality Changes:
The surface and ground water samples reported for 1979 to 1984 are considered pre-implementation (ref. 15). However, an increasing trend in nitrate concentrations in some of the irrigation wells has been identified but no change has been observed in the domestic wells.

19. Changes in Water Resource Use:
Groundwater well samples in the project area showed 8.6% of the wells sampled have nitrate levels above federal standards. As a result of high nitrate levels, some well water is blended with lower nitrate level water to reduce health risks. Total domestic groundwater use has not changed since RCWP began. Recreational use of the project area has been steady since 1976 and fishing continues to be impaired in the project area by high sediment levels.

20. Incentives:
a. Cost Share Rates: 75%
b. $ Limitations: $50,000 per farmer
c. Assistance Programs: SCS develops water quality plans and provides technical assistance. The Extension Service has a 50 acre demonstration farm to display conservation tillage. There are IPM meetings and 4,519 acres were scouted in 1985.
d. Other Incentives or Regulations: RCWP cost share improvements to the feedlots have not been approved in the past because they are considered point sources.

21. Potential Economic Benefits:
a. On-farm: not evaluated
b. Off-farm:
1) Recreation: $5,000 - $50,000 per year.
2) Water Supply: $15,000 - $50,000 per year.
3) Commercial Fishing: 0
4) Wildlife Habitat: unknown
5) Aesthetics: unknown but positive
6) Downstream Impacts: unknown

III. Lessons Learned

Opportunities exist to reduce fertilizer use by transferring manure from large feedlots (defined by the state as point sources) to RCWP participating farms. Cost-shared improvement of feedlots has not been approved, however, in the past because of their legal designation as point sources.
The ground and surface water monitoring Program used in this project aids in prioritizing portions of the watershed for critical area definition. Emphasis on fertilizer and pesticide management is a key factor in dealing with ground and surface water problems simultaneously.

IV. Project Documents

1. Long Pine Creek Nebraska: A Rural Clean Water Program Application. 1981.

2. Plan of Work - Long Pine Creek RCWP Project. October 1981.

3. Monitoring and Evaluation Plan. 1981. 11 + p.

4. Report to Local Coordinating Committee Long Pine Creek Rural Clean Water Program. October 23, 1981. Program Planning Section, Nebraska Department of Environmental Control. 30 p.

5. NDEC Long Pine Intensive Survey Water Quality Update. January 22, 1982.

6. Jensen, D. January 1982. An Index for Assessing the Water Quality of Nebraska Streams. Program Plans Section, Water and Waste Management Division, Department of Environmental Control, State of Nebraska. 57 p.

7. Long Pine Creek Rural Clean Water Program Annual Report:FY 1982.

8. Long Pine Creek RCWP Plan of Work (FY 1983).

9. Long Pine Creek Rural Clean Water Program Annual Report:FY 1983.

10. Long Pine Creek RCWP Plan of Work (FY 1984).

11. Long Pine Creek Rural Clean Water Program Annual Report:FY 1984.

12. Long Pine Creek RCWP Plan of Work (FY 1985).

13. Long Pine Creek Rural Clean Water Program Annual Report: FY 1985.

14. Long Pine Creek Rural Clean Water Program: Plan of Work (FY 1986), revised November 1985. 32 p.

15. Maret, T. December 1985. Water Quality in the Long Pine Rural Clean Water Project 1979-1985. Nebraska Department of Environmental Control, P.O. Box 94877 - Statehouse Station, Lincoln, NE 68509-4877. 194 p.

16. Long Pine Creek Rural Clean Water Program Annual Report: FY1986.

17. Long Pine Creek RCWP: Plan of Work (FY1987), revised November 1986. 30pp.

V. Project Contacts:

Water Quality Monitoring
Don Zaroban or Terry Maret - Surface Water
Dave Chambers - Ground Water
Nebraska Dept. of Environmental Control
301 Centennial Mall South
P.O. Box 94877
State House Station
Lincoln, Nebraska 68509-4877
tel. (402) 471-4432/4700

Land Treatment
Jerry Hardy or Diego Ayala
Soil Conservationist
USDA - SCS
Ainsworth Field Office
Ainsworth, Nebraska 69210
tel. (402) 387-2242

Information and Education
Bud Stolzenburg
Extension Agent
Long Pine Creek RCWP
BKR Cooperative Extension Service
Brown County Courthouse
Ainsworth, NE 69210
tel. (402) 387-2213

Land Treatment
Ray Stenka
ASCS Office
Ainsworth Field Office
R.R. 2
Ainsworth, Nebraska 69210
tel. (402)387-2242

TILLAMOOK BAY - RCWP18

Tillamook County, Oregon
MLRA: A-1
H.U.C. 171002-03

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

This project has made important contributions concerning the effectiveness of animal waste management for improving water quality at the watershed level. To date, the water quality monitoring shows a 40-50% reduction in mean fecal coliform concentration, attributed to bringing approximately 60% of the animal waste produced in the project area under best management. A more thorough knowledge of the marginal water quality benefits of increased manure management should be gained from this project as the total treatment approaches the expected 90% level. The project appears to be cost-effective on a water quality basis. Results from this project indicate that projects that address clearly defined impairments to high-valued recreational resources are most likely to be cost-effective.

II. Project's Characteristics and Results

1. **Project Type:** RCWP

2. **Timeframe:**1981-1991

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): $5,186,715

4. **Cost Share Budget:**
   a. Funds Allocated: $4,383,278
   b. Total Farmers' Contributions: $2,191,600

5. **Water Quality Monitoring Budget:** $344,000 (approx.)

6. **Watershed Area:** 363,520 acres

7. **Project Area:** 23,540 acres

8. **Critical Area:** 9,200 acres

9. **Project/Watershed Land Use:**

use	% project area	% watershed area
cropland	0	0
pasture/range	98	7
woodland	1	89
urban/roads	1	2

10. **Animal Operations in Project Area:**
    a. Dairy: 115 farms with average of 75 cows (8,625 a. u.)
    b. Beef: 95 farms with average of 75 cattle (6,056 a. u.)

11. **Water Resource Type:** streams, estuary, Tillamook Bay

12. Water Uses and Impairments:

Water resources in the project area are used primarily for domestic consumption, recreation and commercial shellfishing. Sport fishing throughout the watershed is a popular activity. Recreational clamming and angling in Tillamook Bay account for approximately 70,000 user-days. Commercial shellfishing in the Bay is a $1.5 million industry (annual gross sales).

The shellfish industry is impaired by excessive fecal coliform levels in the bay. Shellfish harvesting has been closed down frequently during periods of high FC contamination and health hazards exist in tributaries where water contact recreation is popular.

13. Water Quality at Start of Project:

The FC concentration standard for commercial shellfishing waters is a log mean of 14/100ml with no more that 10% of samples allowed greater than 43/100ml. The standards were consistently violated in Tillamook Bay following moderate to large runoff periods.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 90 - 140 inches

b. USLE'R' Factor: 50

c. Geologic Factors: The watershed topography is extremely diverse, from the Coast Range in the east followed by gently to steeply sloping rocky uplands, deeply incised canyons to flat to gently rolling floodplains. The coastline is largely sand dunes, beaches and sedimentary rock outcrops alternating with occasional rugged headlands of volcanic rock. Slopes range from 0 to 90%. Soils are varied, ranging from deep, well-drained coarse-textured bottomland soils with high permeability and slow runoff to well-drained, fine-textured upland soils with moderate permeability and medium to rapid runoff.

15. Water Quality Monitoring Program:

a. Timeframe: 1975 - 1990

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: five small tributary stations; five major river stations, fourteen bay stations.
2. Sampling Frequency: varies, usually monthly, some intensive wet weather samplings
3. Sample Type: grab

c. Pollutants Analyzed: fecal coliform bacteria

d. Flow Measurements: Flow measurements accompany all samples since 7/83. Before then only 2 stations have relatively complete flow records.

e. Other: salinity and turbidity measurements taken in Bay

16. Critical Areas:

a. Criteria: distance to watercourse, present manure management practices; designated subbasins

b. Application of Criteria: Criteria used to prioritize dairy farms for cost sharing.

17. Best Management Practices:

a. General Scheme: All RCWP cost share funds have been focused on BMP-2, Animal Waste Management. Unique BMP components are used in the animal waste systems such as: roofing and guttering of manure storage areas, tidal dikes to prevent high tides from spilling into pastures, and pasture drainage systems to prevent water from standing in pastures where manure is applied.

b. Quantified Implementation Goals: 109 dairies; 8,723 acres

c. Quantified Contracting/Implementation Achievements:

location	% under contract	% implemented
project area	37	22
critical area	93	52
critical area farms	94	54
project area farms	52	36

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
2 Animal waste mgmt.	5,450-6,300 ea.	16,300-18,900 ea.	21,750-25,200 ea.
2 Subsurface drainage	140/ac.	420/ac.	560/ac.
2 curbing/guttering/ diversion	0.50-2.00/ft.	1.44-5.90/ft.	1.94-7.90/ft.
10 fencing	0.13/ft.	0.40/ft.	0.53/ft.

18.Water Quality Changes:

NWQEP analysis indicates that annual log-mean fecal coliform concentrations in both the streams and Bay have decreased significantly since BMP implementation, especially when variations in streamflow and Bay salinity are accounted for. See Tables 1 and 2 below.

Table 1. Tillamook Log Mean Fecal Coliform Concentrations 1975-1981 vs. 1982-1985.

Sampling Sites	Log Mean 1975-1981	Log Mean 1982-1985	% Reduction
Bay 1	49.3	22.4	55 *
Bay 2	55.5	43.2	22 +
Bay 3	82.8	46.5	44
Bay 4	111.0	53.3	52 +
Bay 5a	131.0	31.8	76 *
Bay 6	36.7	20.6	44
Bay 7	33.1	14.5	56 +
Bay 8	20.8	11.6	44
Bay 9	33.3	12.7	62 *
Bay 10	19.8	16.1	19
Bay 11	24.5	13.5	45 +
Bay 12	153.0	123.0	20
Bay 13	23.5	11.7	50 +
Bay 14	49.3	20.0	59 +
Kilchis River	87.0	61.0	30
Miami River	276.0	60.7	78 *
Track River	168.0	63.4	62 *
Tillamook River	387.0	162.0	58 *
Wilson River	147.0	68.6	53 *

* Statistically significant at p = 0.05
+ Statistically significant at p = 0.10

19. Changes in Water Resource Use:

Due to the nonpoint source control project and associated changes in criteria for closing the bay to commercial shellfishing, permanent closure does not appear likely. Commercial oyster production has been steady after low production in 1979 and 1980. Recreational clamming is also likely to be affected by reduced bacteria levels. However, no recreational use figures are currently available to indicate changes attributable to RCWP.

20. Incentives:

a. Cost Share Rates: 75% on BMP-2

b. $ Limitations: $50,000 per landowner. Many animal waste management systems cost more than $66,670. Farmers' share may, therefore, exceed 33%.

c. Assistance Programs: ACP cost sharing has also been used to treat some problems. ACP has a limit of $3,500/yr. for animal waste management systems.

d. Other Incentives or Regulations: Oregon allows a 50% tax credit for conservation measures which can be spread over 10 years. Oregon also has regulations which allow the state to fine agricultural operations that are obvious pollution sources.

21. **Potential Economic Benefits:**
   a. On-farm: not evaluated
   b. Off-farm:
      1) Recreation: $40,000 - $530,000 per year.
      2) Water Supply: 0
      3) Commercial Fishing: $20,000 - $50,000 per year.
      4) Wildlife Habitat: unknown
      5) Aesthetics: unknown
      6) Downstream Impacts: 0

III. Lessons Learned

1. Animal waste management can improve water quality (reduced mean fecal coliform concentrations) when implemented for the critical sources in a 23,000 acre project area.
2. Some measurable indicator of hydrologic state such as precipitation, stream flow, or salinity should be included in water quality sampling programs to identify water quality trends.
3. Thorough records of land treatment accomplishments are essential to attribute water quality trends to BMP implementation.
4. A pre-BMP water quality data base of at least 2 years duration greatly facilitates documenting water quality effects of BMPs.
5. A high level of farmer participation can be achieved when agricultural and water quality agency personnel work together closely on designing and publicizing the program.
6. The combination of financial incentive and environmental regulation is effective in achieving high rates of participation.
7. Agricultural NPS control projects can be very cost- effective if they reduce an impairment to a water resource with high recreational value.
8. Recreational benefits from improved water quality are likely to outweigh commercial fishing benefits even in a region where impaired commercial fishing is the primary concern.

IV. Project Documents:

1. Jackson, J. E. and E. A. Glendening. Oregon Dept. of Environmental Quality. "Tillamook Bay Bacteria Study: Fecal Source Summary Report." January 1982.

2. Tillamook County SWCP and Tillamook Bay Water Quality Committee. January 1981. "Tillamook Bay Drainage Basin Agricultural Nonpoint Source Pollution Abatement Plan".

3. Tillamook Bay RCWP Application. Tillamook County, Oregon. January 1981.

4. Tillamook Bay RCWP. Plan of Work. Tillamook County, Oregon. 1982.

5. Tillamook Bay RCWP Annual Report 1982.

6. Tillamook Bay RCWP Annual Report 1983.

7. Tillamook Bay RCWP Annual Report 1984.

8. Tillamook Bay RCWP Annual Report 1985.

9. Tillamook Bay RCWP Annual Report 1986.

10. Maas, R.P., M.D. Smolen, J. Spooner and A. Patchek. 1987. Benefit/cost analysis of nonpoint source control in the Tillamook Bay, Oregon watershed. Lake and Reservoir Management J., Vol. III, pp. 157-162.

V. NWQEP Project Contacts

Water Quality Monitoring
Andy Schaedel
Oregon Dept. of Environmental Quality
811 S.W. Sixth Ave.
Portland, Oregon 97204
tel. (503) 229-5878

Land Treatment/Technical Assistance
Mr. John Van Calcar
ASCS
U.S. Dept. of Agriculture
Portland, Oregon 97204
tel.(503) 221-2741

CONESTOGA HEADWATERS - RCWP19

Lancaster County, Pennsylvania
MLRA: S-148
H.U.C. 020503-06

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

Project results come from two, intensively monitored field sites. Results are summarized below:
1. Terraces may reduce sediment and nutrient loadings to surface water by reducing the volume of runoff, but in permeable soils with excess manure, terraces appear to increase nitrate transport to ground water and may increase dissolved nutrient concentrations in surface runoff.
2. In this project manurial nitrogen generally exceeds crop needs. Thus, water quality benefits from animal waste storage (e.g., improved timing of applications) are partially offset because nitrogen that could have been volatilized in storage is conserved and applied as a sludge to the soil.
3. Nutrient management BMPs (soil and manure testing, proper matching of application rates, and timing to match plant needs) can reduce both ground and surface water nitrogen losses.

II. Project's Characteristics and Results

1. Project Type: RCWP Comprehensive Monitoring and Evaluation

2. Timeframe: 1981-1991

3. Total Project Budget: (excludes water quality monitoring funds and farmers' contributions) $2,015,513

4. Cost Share Budget:
- a. Funds Allocated: $1,448,000
- b. Total Farmers' Contributions: $285,264 through 1986

5. Water Quality Monitoring Budget: $1,310,000

6. Watershed Area: 110,000 acres

7. Project Area: 110,000 acres

8. Critical Area: 16,000 acres

9. Project/Watershed Land Use:

use	% project area	% watershed area
cropland	44	44
pasture/range	16.4	16.4
woodland	25	25
urban/roads	14	14
other	14	14

10. Animal Operations in Project Area:
- a. Dairy: 445 farms with average of 50 cows (22,098a.u.) and 39 heifers (8,722 a.u.)
- b. Beef: 1,009 beef cattle farms with average of 53 cattle (45,853 a.u.)
- c. Swine: pigs/hogs 7,461 a.u.
- d. Poultry: 15,314 a.u.

11. Water Resource Type: streams, ground water

12. Water Use and Impairments:
Public water supplies originate in the project area for approximately 175,000 people plus 2,000 commercial industries within and downstream from the Conestoga Headwaters (ref. 8). Water resources also support fisheries and contact recreation. Streams used for these activities are impaired by bacteria and sediment. Nitrates impair potable ground water supplies.

13. Water Quality at Start of Project: Two-thirds of wells had nitrate concentrations above 10 mg/l. Maximum concentrations observed were over 100 mg/l.

14. Meteorologic and Hydrogeologic Factors:
a. Mean annual precipitation: 42 inches
b. USLE 'R' factor: 175
c. Geologic Factors: The northeastern two-thirds of the project area lies in the Triassic Lowlands underlain by conglomerate, shale, sandstone and diabase. Average depth to the water table in this area is 15 to 35 feet. The southwestern one-third of the project area is in the Conestoga Valley underlain by carbonate rocks, where average depth to the water table is 20 to 50 feet. Throughout the project area soils are mainly well drained, deep or moderately deep silty loams that provide ample penetration of surface runoff to groundwater supplies.

15. Water Quality Monitoring Program:
a. Timeframe: 1981-1991
b. Sampling Scheme:
1. Location and Number of Monitoring Stations: One 3000 acre watershed with 2 stream gauge sites and 5 additional baseflow sampling sites as well as 5 ground water sites. 2 field sites each with one surface outlet site and seven ground water monitoring wells.
2. Sampling Frequency:
i. Gauged sites: all major storms
ii. Baseflow sites: every 3 weeks
iii. Ground water sites: quarterly (small watershed) monthly (field sites)
3. Sample Type: Grab and automatic
c. Pollutants Analyzed: TSS, nutrients, herbicides
d. Flow Measurements: continuously at gauged sites

16. Critical Areas:
a. Criteria: Small watershed experimental area, and land within carbonate area
b. Application of Criteria: Adherence to the criteria has been undermined by the lack of farmer participation; however, I&E efforts have been focused to the identified critical areas.

17. Best Management Practices:
a. General Scheme: Revised implementation goals include securing 90 contracts to treat about 6,300 acres. New emphasis is on educational programs and nutrient management plans to encourage better nutrient management instead of contracts with cost sharing.
b. Quantified Implementation Goals: The project was revised to emphasize management of animal waste and reduction of commercial fertilizer use.
c. Quantified Contracting/Implementation Achievements (as of September 30, 1986):

location	% under contract	% implemented
project area	5.3	3.8
critical area	36.0	11.4
critical area farms	25.0	not available
project area farms	6.2	not available

d. Cost of BMPs:

Average Installation Cost of BMPs:	
Earthen basin (6 month, manure storage structure)	$12,000
Steel tank (6-month manure storage structure)	$39,000
Contour strip cropping	$30/acre
Winter cover and residue mgmt.	$0 to $20/acre
Terrace systems	$56/acre
Diversion systems (with 20 ft. wide filter strip)	$10/acre
Sod waterway systems	$7/acre

e. Effectiveness of BMPs:
Results of CREAMS model on corn silage following corn silage, 5 percent slope, 30 tons/acre manure application spread daily:

	Soil erosion tons/acre	N loss Ground water	N loss Surface water	P loss
		---------lbs/acre---------		
No BMPs	11	50	68	31
Terraces	3	52	29	12
Reduced-till	6	50	45	20
No-till	3	45	33	14
Multiple BMPs	1	54	14	5

In general, the project believes that nutrient loading reductions will be achieved by reducing nutrient application rates.

f. Cost-effectiveness of BMPs:
Results of modeling continuous corn-grain on a 5 percent slope:

	$/ton of soil saved	$/lb. of N saved	$/lb. of P saved
Terraces	4.87	1.10	2.12
Animal waste systems	NA	0.67	1.50
Diversions	2.06	0.41	0.78
Contouring	1.66	0.33	0.76
Grass waterways	0.99	0.24	0.45
Conservation tillage	.76	0.17	0.34

18. Water Quality Changes:
Thus far, BMP implementation at the project area or small watershed level has not produced significant water quality changes. BMPs have been applied on one field site and their effect on ground and surface waters is being observed.

19.Changes in Water Resource Use:
Only minor changes in water resource use are anticipated since the number of BMPs installed is small relative to the large area affected by the nonpoint source pollution. Localized improvements in individual drinking water wells may occur, however, these improvements will be isolated.

20. Incentives:
a. Cost Share Rates: 50% on animal waste management and soil/manure testing
b. $ Limitations: $ 50,000 maximum
c. Assistance Programs: Project has hired 2 nutrient management specialists and uses a mobile soil/manure testing laboratory

21. Economic Benefits:

The educational gains associated with nutrient management practices have enhanced the work of the Chesapeake Bay and other regional water quality programs. In the long run this may be the greatest benefit from this project. Some on-site benefits are possible from practices that reduce runoff and conserve nutrients for crop production. Off-site benefits associated with expected minor water quality improvement include (discounted 50 year):

Surface water improvements -- $65,000 to $200,000
Groundwater improvements -- $0 to $85,000
Total improvements -- $65,000 to $285,000

III. Lessons Learned:

High cost share rates are needed to gain farmer participation when manure nutrients exceed crop needs and manure has no value to the farmer.

There may be trade-offs between BMPs designed to improve surface and groundwater, complicating treatment of impaired uses if both surface water and groundwater are impaired.

Conservation tillage, nutrient management, and grass waterways are the lowest cost alternatives. Extensive implementation of these over other practices are expected to produce the most water quality results for a given expenditure.

1. Where manure nutrients exceed crop requirements, waste management systems must be designed to reduce the burden on surface and ground waters. Volatilization may be desirable.
2. When on-farm manure nutrients exceed crop needs, manure is a waste product not a resource. High cost share rates, regulations, and export markets for manure should be considered.
3. Targeting is not effective in projects where farmer participation and interest are low.

IV. Project Documents

1. Conestoga Headwaters RCWP. 1982 Plan of Work. Lancaster County, Pennsylvania.

2. Conestoga Headwaters RCWP. Comprehensive Monitoring Program. Revised, October 1982.

3. Conestoga Headwaters RCWP. 1983 Progress Report.

4. Conestoga Headwaters Rural Clean Water Program. 1983 Progress Report. Appendix B, Water Quality Data.

5. Conestoga Headwaters RCWP. 1984 Progress Report.

6. Conestoga Headwaters RCWP. 1985 Progress Report.

7. Crowder, B.M., and C.E. Young. 1986. An Economic Analysis of the Conestoga Headwaters RCWP Project. Draft. Proposed ERS Technical Bulletin.

8. Conestoga Headwaters RCWP. Project Application. February, 1981. Lancaster County, Pennsylvania.

9. Conestoga Headwaters RCWP. 1986 Progress Report.

10. Conestoga Headwaters RCWP. Nutrient Management Plan. 1986.

11. Young, C. Edwin, Bradley M. Crowder, James S. Shortle, and Jeffery R. Alwang. "Nutrient Management on Dairy Farms in Southeastern Pennsylvania." Journal of Soil and Water Conservation, Vol. 40, No. 6, Sept.-Oct., 1985. pp. 443-445.

12. Crowder, Bradley M., and C. Edwin Young. Modeling Agricultural Nonpoint Source Pollution for Economic Evaluation of the Conestoga Headwaters RCWP Project. Staff Report No. AGES850614. Economic Research Service, USDA, Washington, D.C., 1985, 70 pp.

13. Crowder, Bradley M., and C. Edwin Young. "Evaluating BMPs in Pennsylvania's Conestoga Headwaters Rural Clean Water Program." Proceedings: Nonpoint Pollution Abatement Symposium. Marquette University, Milwaukee, WI, 1985, pp. P-III-A-1 - P-III-A-11.

14. Alwang, Jeffery, R. "An Economic Evaluation of Alternative Manure Management Systems and Manure Hauling." Unpublished Master of Science thesis, Department of Agricultural Economic and Rural Sociology, Pennsylvania State University, 1985.

15. Young, C. Edwin, Eugene Lengerich, James G. Beierlein, "The Feasibility of Using a Centralized Collection and Digestion System for Manure: The Case of lancaster County." (In) Proceedings of Conference on Poultry Waste Conversion, (H. C. Jordan and R. E. Graves, eds.), Pennsylvania State University, University Park, PA (1984), pp. 19-26.

16. Young, C. Edwin, Jeffery R. Alwang, and Bradley M. Crowder. Alternatives for Dairy Manure Management. Staff Report No. AGES860422, Economic Research Service, USDA, Washington, D.C., 1986, 35 pp.

17. Crowder, Bradley M. and C.Edwin Young. "Evaluating BMPs in Pennsylvania's Conestoga Headwaters Rural Clean Water Program." Paper presented at Nonpoint Pollution Abatement Symposium, Milwaukee, WI., April 23-25, 1985.

18. Crowder, Bradley M. and C. Edwin Young. "Modeling the Cost Effectiveness of Soil Conservation Practices for Stream Protection." Selected paper presented during the annual meetings, Amherst, MA, June 24-25, 1985.

19. Crowder, Bradley M. and C. Edwin Young. "Managing Nutrient Losses: Some Empirical Results on the Potential Water Quality Effects." Northeast Journal of Agricultural and Resource Economics, Oct. 1986. pp 130-136.

20. Crowder, Bradley and C. Edwin Young. Managing Farm Nutrients -- Tradeoffs for Surface and Groundwater Quality. Agricultural Economic Report Number 583, Economic Research Service, USDA, Washington, DC. Jan. 1988. 22 pp.

V. NWQEP Project Contacts

Water Quality Monitoring

Ms. Patricia Lietman
U.S. Geological Survey
Water Resources Division
P.O. Box 1107
Harrisburg, PA 17108
tel. (717) 782-3860

Mary Jo Brown
PA Dept. of Environmental Resources
Bureau of Water Quality Management
One Ararat Blvd.
Harrisburg, PA 17110
tel. (717) 657-4590

Land Treatment/Technical Assistance

Richard Pennay
Agricultural Stabilization and Conservation Service
Federal Bldg.
Harrisburg, PA 17108
tel. (717) 782-4593

Economic Evaluation

C. Edwin Young
Economic Research Service
U.S. Dept. of Agriculture
1301 New York Ave. NW, Rm. 508
Washington, DC 20005-4788
tel. (202) 786-1401

OAKWOOD LAKES - POINSETT - RCWP20

Brookings, Kingsbury and Hamlin Counties, South Dakota
MLRA 102-A
H.U.C. 101702-01,02

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project started water quality monitoring relatively recently (1984). Preliminary analysis suggests that agricultural fertilizer contributes nitrate to a holding area in the soil profile from which nitrate is leached to ground water on a continual basis. In the future, the project will contribute more information on the transport of nutrients and pesticides from the soil surface to ground water.

II. Project's Characteristics and Results

1. **Project Type:** RCWP, Comprehensive Monitoring and Evaluation Project

2. **Timeframe:** 1981-1991

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): $1,720,753

4. **Cost Share Budget:**
   a. Funds Allocated: $1,240,886
   b. Farmers' Contributions: not available

5. **Water Quality Monitoring Budget:** not available

6. **Watershed Area:** Lake Poinsett - 7,868 acres draining 32,452 acres
   Lake Albert - 2,400 acres within Lake Poinsett watershed
   Oakwood Lakes - 2,184 acres draining 52,856 acres

7. **Project Area:** 106,163 acres (includes surface and groundwater area)

8. **Critical Area:** 79,450 acres of cropland and grassland

9. **Project/Watershed Land Use:** (ref. 7)

use	% project area
cropland	61.5
grassland	13.3
water	9.9
other	15.3

   There are 304 farms in the critical area.

10. **Animal Operations in Project Area:** (est. October 1985, ref. 7) (in the Priority 1 Critical Area)
    a. Dairy: 830 a.u.
    b. Beef: 2,167 a.u.
    c. Swine: 1,350 a.u.
    d. Sheep: 37.5 a.u.

11. **Water Resource Type:** three main lakes, ground water (portions of the Big Sioux aquifer)

12. **Water Uses and Impairments:**
The project area has numerous lakes, sloughs and shallow ground water aquifers bordering on the Big Sioux aquifer. The lakes are heavily used for recreation (e.g., fishing, boating, swimming, water-skiing) and stock watering. Over the past five years, recreational visitations to the lakes numbered 240,000 to 300,000 annually. Ground water is relied upon for drinking water and stock watering. Approximately 174,000 people live within fifty miles of the lakes.
Recreational activities are impaired by hypereutrophic conditions in the lakes. Algal blooms, excessive aquatic weed growth, and DO depletion are common. Pesticides and excessive nitrates in ground water are also of primary concern.

13. **Water Quality at Start of Project:** (ref. 7)
Groundwater: Water quality data (1977-1978 study) from 861 private wells in the project area showed nitrate levels exceeding the federal drinking water standard (10mg/l) in 27% of the wells tested.

	Total P (mg/l)	Total N (mg/l)
Lake Poinsett:	0.12	4.0
Oakwood Lakes:	0.15	9.0
Tributaries:	0.50	3.2

14. **Meteorologic and Hydrogeologic Factors:**
a. Mean Annual Precipitation: 22 inches
b. USLE 'R' Factor: ~ 100
c. Geologic Factors: The project area has typical glacial Pleistocene morphology with many alluvial outwash deposits, lakes, potholes and shallow ground water resources. Soils are deep, silty, loamy and well drained on rolling slopes. Generally, the water table is about 10 feet below ground level. Ground water flow is active and a large aquifer, the Big Sioux, underlies a portion of the project area.

15. **Water Quality Monitoring Program:**
a. Timeframe: 1984 - (not specified in NWQEP documents)
b. Sampling Scheme:
1. Location and number of monitoring stations: There are seven field sites and one master (experimental) site with nests of wells at each site. The sites are located in different parts of the project area at locations selected to represent predominant cropping practices on glacial till or outwash soils. A control site is located on non- agricultural land.
2. Sampling frequency: ground water - monthly; surface runoff - storm event based
3. Sample type: automatic and grab
c. Parameters Analyzed:
ground water- NO_2-N & NO_3-N, NH_3, organic N, TP, CL, SO_4, pesticides, pH, conductivity, DO, TKN
surface runoff - ground water parameters plus ortho P, TDS and SS
Flow is measured with surface runoff samples. Ground water levels are measured on a weekly to monthly basis.
d. Other: As an extension of the CM&E project, a special monitoring study of the Oakwood Lakes began in 1987. The study has two years of funding to produce annual and seasonal sediment, phosphorus and nitrogen budgets for the Oakwood lakes during 1987 and 1988. Six monitoring stations are located on tributaries, three sites are between lake basins, and one site is at the lake outlet. At tributary stations base flow is measured biweekly to monthly and water quality samples are taken automatically after storm events. Parameters sampled are TP, ortho P, NO_3-N & NO_2-N, NH_3, TKN and SS. At in-lake sites, integrated samples are taken every two weeks from May to October and every month from November to April. Parameters sampled are TP, ortho P, NO_3-N & NO_2-N, NH_3, TKN, pH, chl *a*, algal density, DO, temperature, and secchi disk transparency. Biological sampling of fish populations and zooplankton also takes place.

16. **Critical Areas:**
a. Criteria: The entire 79,450 acres of cropland and grassland are considered critical. The project area was divided into three priority areas based on sediment delivery levels and the impact on ground water

(e.g., regional ground water movement, distance from lakes or streams, drainage characteristics, and thickness of overburden). The first priority area covers 59,500 acres. The second and third priority areas cover 19,950 acres combined.
b. Application: The first priority area includes most of the livestock operations and encircles the lakes.

17. Best Management Practices:
a. General Scheme:
— reduce nutrients and pesticides entering ground water using fertilizer and pesticide management (BMP 15 & 16)
— reduce sediment related pollutants entering waterways and lakes using conservation tillage (BMP 9)
— reduce amount of animal waste entering waterways, lakes and ground water by applying waste management systems
b. Quantified Implementation Goals:
—fertilizer management on 70,000 acres (66% of project area)
—pesticide management on 65,000 acres (61% of project area)
—sediment control BMPs applied and/or maintained on 65,000 acres
—waste management systems on 10 livestock operations
c. Quantified Contracting/Implementation Achievements:

	%under contract	% implemented
project area	41.1	not available
critical area	55.0	not available
critical area farms	49.0	not available
project area	not available	not available

Three feedlots have been brought under best management.

d. Cost of BMPs: Estimated cost of the three major BMPs being implemented are:

	Govt. cost share	Tech. Asst. cost	Total Gov. cost	Years of life
	per acre			
Conservation tillage	22.50	1.09	23.59	3+
Fertilizer management	3.00	72.00	3.72	4+
Pesticide management	-0-	4.29	4.29	3

e. Effectiveness of BMPs:

BMP	soil savings (tons)	applied units
Perm. veg.cover	5,935	1,025 ac.
Strip cropping	125	132 ac.
Terrace systems	215	7,491 ft.
Waterways	6	3 ac.
Shelterbelt	620	1,489 rod rows
Cons. tillage	160,700	24,677 ac.

18. Water Quality Changes:
Simulation with the AGNPS model indicates that all contracted BMPs implemented as of July 1986, should reduce sediment and phosphorus loadings to the four major lakes by 5 to 12 percent compared with pre-RCWP loadings. However, the model also indicates that water soluble nitrogen loadings should increase 2 to 3 percent. The model provides no estimates of changes in nitrogen infiltration.

19. Changes in Water Resource Use:
The projected reductions in loadings to the lakes as a result of RCWP do not appear sufficient to affect water quality and water use. No findings are yet available on ground water use.

20. Incentives:

a. Cost Share Rates: 75%

b. $ Limitations: $50,000 maximum per farm

c. Other Incentives: I & E programs

21. Economic Benefits:

a. On-farm:

Participating farmers appear to benefit economically from reduced tillage costs, reduced fertilizer costs, and perhaps slightly lower pesticide costs. Also there may be some short and long-term yield improvement attributable to soil and moisture retention by conservation tillage.

b. Off-farm:

Recreational values are so high that reducing algae blooms could generate benefits as high as $3.5 to $5.9 million annually. Actual recreational benefits attributable to RCWP will likely be much less, however, because reductions in nutrient loadings to lakes will probably be small. Domestic water supply benefits could reach $100,000 annually if groundwater quality is maintained above public health standards.

IV. Lessons Learned

The project is developing a method for aggregrating ground water data. With only two full years of data, analysis of potential changes in water quality as a result of BMP implementation remains limited. Currently, monitoring data is providing the project with increased understanding of the complex hydrogeology in this project area. The AGNPS model is being used to predict the effect of BMP implementation on sediment, P and N loadings to surface waters, and the project is documenting the effect of fertilizer management on the quality of ground water.

IV. Project Documents

1. Application for RCWP Funds, February 1981.

2. Comprehensive Monitoring and Evaluation Plan for the Oakwood Lakes - Poinsett RCWP, South Dakota State Coordinating Committee, July 1982.

3. 1982 Annual RCWP Progress Report - Project 20, Oakwood Lakes - Poinsett, South Dakota.

4. 1983 Annual RCWP Progress Report - Project 20, Oakwood Lakes - Poinsett, South Dakota.

5. 1984 Annual RCWP Progress Report - Project 20, Oakwood Lakes - Poinsett, South Dakota.

6. 1985 Annual RCWP Progress Report - Project 20, Oakwood Lakes - Poinsett, South Dakota.

7. 1986 Annual RCWP Progress Report - Project 20, Oakwood Lakes Lakes - Poinsett, South Dakota.

8. Piper, Steve, Mark Ribaudo, and A. Lundeen. "The Recreational Benefits from an Improvement in Water Quality of Oakwood Lakes and Lake Poinsett South Dakota." North Central Journal of Agricultural Economics, vol. 9, no. 2, 1987. pp. 279-288.

V. NWQEP Project Contacts:

Water Quality Monitoring

Jeanne Goodman
SD Dept. of Water & Natural Res.
Water Resource Institute (WRI)
South Dakota State University
Box 2120
Brookings, SD 57007
tel. (605) 688-5025

Land Treatment/Technical Assistance

Dee Watson
USDA - SCS
619 5th Ave.
Brookings, SD 57006
tel. (605) 692-8464

Information and Education
Charles H. Ullery
Water & Natural Res. Specialist
CES
229 Agricultural Engineering
South Dakota State University
Box 2120
Brookings, SD 57007
tel. (605) 688-5141

Economic Evaluation
Richard Magleby
Economic Research Service/RTD
U.S. Dept. of Agriculture
1301 New York Ave. NW, Rm. 532
Washington, DC 20005-4788
tel. (202) 786-1435

NANSEMOND-CHUCKATUCK - RCWP 21

City of Suffolk and Isle of Wight County, Virginia
MLRA: T-153A
H.U.C. 020802-08

I. Project's Major Contribution Toward Understanding the Effectiveness of NPS Control Efforts

The project is not evaluating the effectiveness of individual BMPs but the water quality data and detailed land treatment records should make possible the analysis of the project's impact on water quality.

II. Project's Characteristics and Results

1. Project Type: RCWP

2. Timeframe: 1981-1991

3. Total Project Budget: $1,929,995

4. Cost Share Budget:
  a. Funds Allocated: $1,721,000
  b. Total Farmers' Contributions: $4,242,000 estimated as of 1991

5. Water Quality Monitoring Budget: $118,400

6. Watershed Area: 161,365 acres

7. Project Area: 161,365 acres

8. Critical Area: 23,917 acres (expanded from 18,749 in 1985-ref.17)

9. Project Land Use: (equivalent to watershed land use)

use	% project area	% watershed area
cropland	29.1	29.1
pasture/range	2.8	2.8
woodland	62.5	62.5
urban/roads	1.2	1.2
other	4.4	4.4

There are 825 farms in the project area.

10. Animal Operations in Project Area:
  a. Dairy: 125 a.u.
  b. Beef: 2,315 a.u.
  c. Swine: 7,200 a.u.
  d. Poultry: 2,240 a.u.

11. Water Resource Type: 2 estuaries and 7 drinking water reservoirs

12. Water Uses and Impairments:
Reservoirs in the project area are sources of public water supply for the cities of Norfolk, Chesapeake and Virginia Beach, Virginia. Chuckatuck Creek is a successful shellfish growing area and a tidal tributary to the James River. Commercial and recreational fishing and shellfishing are important water

uses. The reservoirs are becoming eutrophic due to sediment and nutrients. Tidal waters are impaired by high fecal coliform levels.

13. Water Quality at Start of Project:

Estuary: 3,000 acres of shellfish beds have been condemned, chl *a* concentrations exceed 40 ug/l, and DO is frequently depleted.

Reservoirs: Phosphate-P concentrations range from 0.05 to 0.20 mg/l in fall and winter samples. Higher concentrations have been associated with high fecal coliform densities in some tributaries to the reservoirs.

14. Meteorologic and Hydrogeologic Factors:

a. Mean Annual Precipitation: 48 inches

b. USLE 'R' Factor: 300

c. Geologic Factors: The project area is characterized by nearly level to gently rolling topography with steep slopes adjacent to small tributary streams. Most soils have moderately low erodibility factors. Depth to groundwater is generally 25 feet or more.

15. Water Quality Monitoring Program:

a. Timeframe: sampling of reservoirs was initiated October 1982; regular sampling of estuary stations initiated in June 1983.

b. Sampling Scheme:

1. Location and Number of Monitoring Stations: 19 sampling stations – 4 in the Nansemond River estuary, 3 in the Chuckatuck Creek estuary, and 12 stations in the upstream impoundments of the Nansemond River system
2. Sampling Frequency: at each station is conducted monthly.
3. Sample Type: grab

c. Pollutants Analyzed:

estuary: DO, salinity, TSS, NO_3, dissolved OP, FC, BOD

impoundments: TS, TP, pH, FC, DO, BOD, algal species

d. Other: There are no flow measurements.

16. Critical Areas:

a. Criteria: The boundary was originally specified to include the area one mile from the Nansemond River or its impoundments and one mile from Chuckatuck Creek. This was expanded during 1985 to include most of the remaining project area (new boundary includes 1 mile radius from all tributaries). In treating the expanded critical area, the project established a priority checklist for ranking. Weights are based primarily on distance to live stream and less than optimal soil or animal waste management. Animal waste operations are given twice the priority of croplands, and erosion problems are given the same priority as pesticide and fertilizer management problems. Farms with animal operations and no cropland treatment needs do not qualify.

b. Application of Criteria: Project reports do not contain appropriate detail to evaluate this.

17. Best Management Practices:

a. General Scheme: The project has concentrated primarily on animal waste management, for hog and dairy operations, and conservation tillage with fertilizer and pesticide management.

b. Quantified Implementation Goals: The project seeks to treat 17,931 acres and 115 animal operations. These goals expanded from 14,055 acres and 51 animal operations in 1985, when the critical area was expanded.

c. Quantified Contracting/Implementation Achievements: (ref. 18, p.21)

location	% Under Contract	% Implemented
project area	9.3	NA
critical area	62.8	NA
critical area farms	NA	NA
project area farms	NA	NA

d. Cost of BMPs:

BMP	Ave. Farmer Share ($)	Ave. RCWP Share ($)	Total Cost ($)
1 Perm. Veg. Cover	33/ac.	100/ac.	133/ac.
2 Animal Waste Mgmt.	6,670 ea.	20,000 ea.	26,670 ea.
5 Diversion System	0.33/ft.	1/ft.	1.33/ft.
6 Grazing Land Protection	1,670 ea.	5,000 ea.	6,670 ea.
7 Waterway System	83/ac.	250/ac.	333/ac.
8 Cropland Protection	5/ac.	5/ac.	10/ac.
9 Conservation Tillage	7.30/ac.	22/ac.	29.30/ac.
11 Perm. Veg. on Crit. Areas	35/ac.	105/ac.	140/ac.
12 Sediment Retention Struc.	750 ea.	2,250 ea.	3,000 ea.

e. Effectiveness of BMPs: The project estimates that 45,108 tons of soil have been protected from erosion annually, and 56,546 tons of manure produced annually (65% of production) have been put under management.

18. Water Quality Changes:

Water quality data have not yet been analyzed. Improving trends in TSS and orthophosphorus have been observed for Nansemond River when compared with reports from the 1960s. An improving trend in NO_3-N has been observed for Chuckatuck Creek. However, these trends may not be attributable to RCWP work because they originated in the late 1960s after point sources removed from the project area. Analysis of water supply lakes in the project area indicates high variability in water quality data and little evidence of trends.

19. Changes in Water Resource Use:

Oyster production has decreased from a total of 214,000 pounds in 1980 to 95,400 pounds in 1985. Lowest production was in 1984 with 57,800 pounds. Three reservoirs in the project area are used for domestic water supply, and water treatment has not changed since RCWP began. Fishing is the primary recreational activity in the area, with approximately 30,100 user days per year, unchanged since 1980. Of 7,200 total shellfishing acres, 2,100 acres are condemned and 2,700 acres have been conditionally approved.

20. Incentives:

a. Cost Share Rates: 75% for most practices except cover crops and some waste application equipment cost shared at 50%. Fertilizer and Pesticide management are not cost shared.
b. $ Limitations: $50,000 per contract (some contracts cover multiple tracts) c. No other assistance programs or regulations are utilized to encourage participation.

21. Potential Economic Benefits:

a. On-farm: not evaluated
b. Off-farm:
  1) Recreation: 0
  2) Water Supply: $10,000 - $130,000 per year
  3) Commercial Fishing: $30,000 per year
  4) Wildlife Habitat: unknown
  5) Aesthetics: unknown
  6) Downstream Impacts: unknown but positive

III. Lessons Learned

This project shows a high degree of coordination among agencies concerned with water quality and resources. The land treatment program is implemented by SCS. SCS keeps appropriate records to identify each contract with respect to the water resource that it affects. Several water resource agencies are conducting monitoring programs that are used to assess the effectiveness of the land treatment program. The monitoring agencies interface with the land treatment program through a coordinator at the Hampton Roads Water Quality Agency. The agencies appear to maintain effective communication.

IV. Project Documents

1. RCWP Local Coordinating Committee, County of Isle of Wight and the City of Suffolk, Southeastern Virginia. Nansemond-Chuckatuck Rural Clean Water Project, City of Suffolk and Isle of Wight County, Project Proposal. 1980. (includes the following Appendices:

a. Presnell-Kidd Assoc., Inc. (for City of Norfolk, Va. Dept. of Utilities) Phase 1 Water Quality Management Study Norfolk-Western Lakes Reservoir Systems. (no date)

b. Virginia State Water Control Board. Chuckatuck Creek Non-point Source Bacteriological Study. April 24, 1980.

c. Virginia Department of Health. Notices of Shellfish Area Condemnation for Chuckatuck Creek dated: 28 June 1979; Nansemond River dated 16 August 1976, 9 March 1972, and 6 November 1963.

d. Virginia State Water Control Board. State Water Quality Management Plan for the Hampton Roads Planning Area. Adopted March 23-25, 1980.

e. Kilch, L.R. and B.R. Neilson. Field and Modeling Studies of Water Quality in the Nansemond River. A report to the Hampton Roads Water Quality Agency. Special Report No. 133 in Applied Marine Science and Ocean Engineering. Virginia Institute of Marine Science. Gloucester Point, Va. December 1977.

f. Hampton Roads Water Quality Agency. Hampton Roads Water Quality Management Plan. Executive Summary. (Draft, no date)

g. City of Norfolk, Department of Utilities. Summary Report. Western Reservoir System Water Quality Management Plan-Phase II. June 1980.

2. USDA-SCS and VPI&SU. Soil Survey of City of Suffolk, Va. June 1981.

3. RCWP Local Coordinating Committee. Nansemond-Chuckatuck Rural Clean Water Project Plan of Work. October 1981.

4. Cox, C.B. Nonpoint Pollution Control: Best Management Practices Recommended for Virginia. Special Report No. 9. Virginia Water Research Center, Blacksburg, VA. November 1979.

5. VPI&SU Extension Division. Best Management Practices in Agriculture and Forestry. Publication 4 WCB 1. Blacksburg, Va. January 1980.

6. VPI&SU Extension Division. Best Management Practices for the Urban Dweller. Publication 4 WCB 2. Blacksburg, Va. April 1980.

7. VPI&SU Extension Division. Best Management Practices for Row-Crop Agriculture. Publication 4 WCB 3. Blacksburg, Va. June 1980.

8. VPI&SU Extension Division. Best Management Practices for Beef and Dairy Production. Publication 4 WCB 4. Blacksburg, Va. July 1980.

9. VPI&SU Extension Division. Best Management Practices for Swine Operations. Publication 4 WCB 5. Blacksburg, Va. November 1980.

10. VPI&SU Extension Division. Best Management Practices for Tobacco Production. Publication 4 WCB 6. Blacksburg, Va. January 1981.

11. VPI&SU Extension Division. Conservation Tillage a Best Management Practice. Publication 4 WCB 7. Blacksburg, VA. January 1981.

12. VPI&SU Extension Division. Integrated Pest Management - a Best Management Practice Publication 390-409. Blacksburg, VA. November 1980.

13. Nansemond-Chuckatuck RCWP Best Management Practices, as approved by EPA in letter from Peter Wise to Orin Hanson, May 14, 1981.

14. RCWP Local Coordinating Committee. Nansemond-Chuckatuck RCWP 1982 Progress Rep. Nov. 1982.

15. RCWP Local Coordinating Committee. Nansemond-Chuckatuck RCWP 1983 Progress Rep. Nov. 1983.

16. RCWP Local Coordinating Committee. Nansemond-Chuckatuck RCWP 1984 Progress Rep. Nov. 1984.

17. RCWP Local Coordinating Committee. Nansemond-Chuckatuck RCWP 1985 Progress Rep. Nov. 1985.

18. RCWP Local Coordinating Committee. Nansemond-Chuckatuck RCWP 1986 Progress Rep. Nov. 1986.

19. Neilson, B.J. Nonpoint Source Sampling in the Hampton Roads Area. A report to the Hampton Roads Water Quality Agency. Special Report No. 128 in Applied Marine Science and Ocean Engineering. Virginia Inst. of Marine Sciences. March 1977.

20. Neilson, B.J. Summary of the Hampton Roads 208 Water Quality Modeling Studies. A report to the Hampton Roads Water Quality Agency. Special Report No. 170 in Applied Marine Science and Ocean Engineering. Virginia Inst. of Marine Sciences. January 1978.

21. Bosco, C. and Neilson, B.J. Interpretation of Water Quality Data from the Nansemond and Chuckatuck Estuaries with respect to Point and Nonpoint Sources of Pollution. A report to the Hampton Roads Water Quality Agency. Virginia Inst. of Marine Sciences. May 1983.

22. Kerns, W.R. R.A. Kramer, W.T. McSweeney, R. Greenough, and R.W. Stavros. Nonpoint Source Management: A Case STudy of Farmers' Opinions and Policy Analysis. Unpublished Report. Virginia Polytechnic Inst. and State University. Blacksburg, Va. November 1982.

23. Kramer, R.A. and D.L. Faulkner. Income Tax Provisions Related to Agricultural BMPs. (Working Draft) Agricultural Economics Department. Virginia Polytechnic Inst. and State University. Blacksburg, Va. (no date)

V. NWQEP Project Contacts:

Water Quality Monitoring
Paul Fisher
Hampton Roads WQ Agency
The Regional Bldg.
723 Woodlake Drive
Chesapeake, VA 23320
tel. (804) 420-5364

Information and Education
Charlie Perkins
Virginia Coop. Ext. Service
P.O. Box 364
Windsor, VA 23487
tel. (804) 242-6195

Land Treatment/Technical Assistance
Harry O. Dalton
SCS
200 N. Main St.
B-19
Suffolk, VA 23434
tel. (804) 539-9270

LAKE LE-AQUA-NA

Stephenson County, Illinois
MLRA: M-108
H.U.C. 070900-03

I. Project's Major Contribution Toward Understanding the Effectiveness of NPS Control Efforts

This project has an integrated approach to watershed management that includes land use and in-lake treatment. It has a strong probability of achieving its goal of cleaning up the lake, but it may not fully document the effectiveness of the BMPs implemented in the watershed. It also has the potential to demonstrate the effectiveness of conservation tillage. Project organization at the local level contributed considerably to the successful implementation of this project.

II. Project's Characteristics and Results

1. **Project Type:** Clean Lakes Program along with the Agricultural Conservation Program and the Illinois Dept. of Conservation

2. **Timeframe:** Phase I 1981-1983 Phase II 1984-1987

3. **Total Project Budget** by Project Components:
   Phase I Study (baseline water quality study): $51,750
   Federal ACP Special Project (for implementation of conservation tillage): $38,000
   Phase II (in-lake treatment and terracing of 2 parcels of land): $56,163
   Matching funds $56,163
   State ACP Special land treatment: $26,500
   Supplemental Phase II: $36,465
   Matching funds: $36,465

4. **Cost Share Budget:**
   a. Funds Allocated: $118,760
   b. Total Farmer's Contributions: $29,235

5. **Water Quality Monitoring Budget:** Phase I $23,000 Phase II 41,821 Total $64,821

6. **Watershed Area:** 2,348 acres

7. **Project Area:** 2,348 acres

8. **Critical Area:** 1500 acres cropland, with 200 acres requiring practices in addition to conservation tillage.

9. **Project Land Use:** (equivalent to watershed land use) (ref. 2 p.19)

Use	% project area
cropland	66.9
pasture/range	7.8
woodland	17.7
urban/roads	1.4
other	6.2

10. Animal Operations in Project Area: (ref. 1)
There are 7 livestock operations in the watershed, with 5 having more than one type of livestock. Overall there are:
a. Dairy: 145 cows (145 a.u.)
b. Beef: 30 heifers and 216 cattle (184 a.u.)
c. Swine: 630 pigs/hogs (189 a.u.)
d. Sheep: 20 sheep (4 a.u.)

11. Water Resource Type: Streams and impoundment, Lake Le-Aqua-Na

12. Water Uses and Impairments:
The lake's impairments are loss of lake capacity, impaired fishing, boating and aesthetics due to nutrient and sediment loading causing algal blooms, excessive aquatic macrophytes, dissolved oxygen depletion, turbidity and sedimentation.

13. Water Quality at Start of Project: (ref. 2, p. 4)
1981 Mean Lake Concentrations:

Pollutant	Concentration (mg/l)
Total Phosphorus	0.323
Dissolved Phosphorus	0.27
Inorganic Nitrogen	1.85

Chlorophyll *a* ranged from 2 to 243 ug/l with mean = 89.4 ug/l; nuisance algal blooms dominated by blue-green algae were present. During peak stratification, 51% of lake volume was anoxic. Several winter fish kills have occurred.

14. Meteorologic Factors:
a. Mean annual Precipitation: 34.35 inches
b. USLE 'R' Factor: ~175

15. Water Quality Monitoring Program:
a. Timeframe: 1981-1986
b. Sampling Scheme (location, number, frequency, and sample type):
1. One station located on a stream, just above discharge into the lake, is grab sampled after storm events exceeding 2 inches in 48 hours, as well as monthly October - April, and biweekly May-September.
2. Three in-lake stations: grab sampled monthly from October to April and biweekly from May to September.
3. One station downstream from dam - same sampling frequency as upstream station (#1).
c. Pollutants Analyzed:
1. Stream station: TSS, VSS, turbidity, TP, NH_3, NO_2 and NO_3
2. In-lake stations: DO, temperature, pH, alkalinity, conductivity, Secchi, TSS, total dissolved solids, VSS, turbidity, TP, dissolved phosphorus, NO_2 and NO_3, NH_3, TKN, chl *a*, chl *b*, chl *c*, pheophytin
d. Flow Measurements: instantaneous discharge measurements during scheduled sampling visits (monthly April - October, biweekly May - September)
e. Other: precipitation; sampling of lake benthic organisms; phytoplankton; mapping of macrophytes

16. Critical Areas:
a. Criteria: Criteria for selection were (1) distance to water course and (2) erosion rate
b. Application of Criteria: Appears to be consistent.

17. Best Management Practices: (ref. 3)
a. General Scheme: Consisted mainly of conservation tillage with some terracing, stripcropping, waterways, sediment basins, and stream bank protection. Non-BMP, in-lake treatments include: (1) lake destratifier, (2) macrophyte harvesting, (3) chemical algae control ($CuSO_4$), and shoreline stabilization.
b. Quantified Implementation goals: The goal of the ACP project was to increase average ground cover

from 20% to 40% on the tillable land and thereby reduce average soil loss on cropland 42%.
c. Quantified Contracting/Implementation Achievements: There appears to be land treatment on about two-thirds of the watershed, which is all of the cropland. Most of this treatment is conservation tillage. All of the 200-acre critical area has been treated with BMPs such as terracing, water and sediment control structures, stripcropping, and streambank stabilization measures.
d. Effectiveness of BMPs: Erosion control estimated as 5,250 tons/year on cropland, 1,740 tons/year prevented from reaching lake (57% reduction).

18. Documented Water Quality Changes:
No statistically significant changes were reported through 1984; however, visual improvement was reported.

19. Incentives:
a. Cost Share Rates: Cost share payment for conservation tillage varied with the amount of residue left. Other practices received 80% cost share.
b. $ Limitations: $3,500 for ASCS LTA
c. Assistance Programs: Technical assistance for BMP implementation

III. Lessons Learned

Comparisons (two sample t-test) of 1981 to 1984 water quality data from both the stream and the lake stations showed no significant differences; however, the means of most parameters were lower in 1984 than in 1981. Use of stronger statistical analyses may verify significant decreases over this period. The effects of only the BMP implementation on water quality may be difficult to document due to: (1) there is only one monitoring station that is not effected by in-lake treatments and (2) extremes in precipitation variability occurred during the monitoring period. Visual improvement in the appearance of the lake has been reported. In this respect, the project may be successful with its lake protection/restoration program and may increase the recreational benefits of the area whether or not improvement is verified by chemical monitoring.

IV. Project Documents

1. Kotlandaramar, V. and R. L. Evans (Illinois State Water Survey) 1983. Clean Lakes Program Phase I Diagnostic/Feasibility study of Lake Le-Aqua-Na, Stephenson County, Illinois. 158 pp.

2. Davenport, T.E., D.F. Sefton, and S.K. Chick, 1985. Lake Le-Aqua-Na: A Cooperative Approach to Resource Conservation. Presented at the EPA Region V Workshop (November 1985).

3. Sefton, D.F. and J.D. Mitzelfelt, 1987. Clean Lakes Program Phase II Project Report for Lake Le-Aqua-Na, Stephenson County, Illinois. Illinois EPA. (in preparation)

V. NWQEP Project Contact

Donna Sefton
Illinois EPA
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276
tel. (217) 782-3362

Blue Creek Watershed

Pike County, Illinois
MLRA
H.U.C. 071300-11

I. Project's Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

The project demonstrated that land treatment practices can reduce soil erosion and improve water quality. The project is unique in its attempt to relate changes in water quality to three periods of land use (1. fertilizer and seedbed establishment, April - June; 2. plant reproduction and maturation, July - November; and 3. plant residues, December - March).

The project used computer models to enhance the USLE, to determine the effectiveness of reduced tillage, and to determine the relative off-site impacts of best management practices.

The project employed a carefully designed monitoring program to monitor the effects of BMP installation on different areas of the watershed, from one specific practice to an entire sub-basin.

II. Project's Characteristics and Results

1. **Project Type:** ACP Special Water Quality Project

2. **Timeframe:** 1979 - 1982

3. **Total Project Budget:** not available

4. **Cost Share Budget:**
   a. Funds Allocated: $313,945
   b. Farmers' Contributions: not available

5. **Water Quality Monitoring Budget:** not available

6. **Watershed Area:** 7,012 acres

7. **Project Area:** 7,012 acres

8. **Critical Area:** not available (approximately half the project area)

9. **Project Land Use:**

use	% of project area
cropland (corn, soybeans, wheat)	56.4
pasture/hayland	21.7
woodland	11.6
other (wildlife, farmstead, feedlots, water)	10.3

10. **Animal Operations in Project Area:** 460 acres of hog and cattle feedlots on 21 farms.

11. **Water Resource Type:** Blue Creek and its tributaries drain into Pittsfield City Lake, a multiple use reservoir constructed in 1961.

12. Water Uses and Impairments:
Use of Pittsfield City Lake was impaired for secondary contact recreation (fishing and boating) and for public water supply for about 4,400 residents in the City of Pittsfield. Impairment was caused primarily by sediment deposition in Pittsfield City Lake. Nutrients and pesticides were also of concern.

13. Water Quality at Start of Project:
Slightly more than one percent of lake capacity was lost to sedimentation annually. At this rate the lake would have been completely filled in 92 years.

14. Meteorologic and Hydrogeologic Factors:
a. Mean Annual Precipitation: 37.35 inches
b. USLE 'R' Factor: 175
c. Geologic Factors: Hilly terrain, steep slopes, and fine-textured soils which are almost entirely glacial in origin. Topography ranges from nearly level to gently sloping.

15. Water Quality Monitoring Program:
a. Timeframe: 1980 - 1982
b. Sampling Scheme:
1. Location: Blue Creek was monitored at two locations (stations C & B) representing 50% and 70% of the drainage area, respectively. A station (A) was also located at the watershed outflow and a station (D) was located on a direct tributary to the lake to determine the relative contribution of a major sub-basin. Two field stations (E & F), 38 and 79 acres, were monitored for comparative information on field level conditions. One station (J) was maintained to monitor the effectiveness of a vegetative filter strip installed to control runoff from a feedlot operation. Lake monitoring took place at three locations. In addition, there were four biological monitoring stations in the watershed.
2. Frequency: daily - stations B,C / weekly - stations A,B,C / monthly - lake sites / event basis - all stations
3. Sample Type: automatic and grab
c. Primary Pollutants Analyzed: TSS, TVS, NH_3, TKN, TP, $N0_3$, DP, BOD, COD
d. Flow Measurements: streamflow measured daily / flow measurements for ephemeral streams taken only during rainfall-runoff events
e. Other Measurements: temperature, pH, conductivity, plus several chemical parameters

16. Critical Areas:
a. Criteria: locally designated (specific criteria not reported)
b. Application: not available

17. Best Management Practices:
a. General Scheme: Emphasis was placed on reducing soil erosion using the following practices: contouring, stripcropping, no-till, reduced tillage, terracing, streambank protection, vegetative filter strips, waterways, permanent vegetative cover and livestock exclusion.
b. Quantified Implementation Goals: The project's goal was to reduce soil loss by 23,587 tons. (Potential gross erosion for the watershed was estimated to be 63,313 tons/year of which 99% was sheet and rill erosion).
c. Quantified Contracting/Implementation Achievements:

	% Project Area
Treated with cost share	28.3
Treated without cost share	8.5

d. Effectiveness of BMPs: As of October 1, 1982, 88% of the soil loss reduction goal had been achieved -- soil erosion had been reduced by 20,674 tons per year.

18. Documented Water Quality Changes: (ref. 9)
There is an overall trend of decreasing mean TSS in stream samples from 1979 - 1982. Turbidity in Pittsfield City Lake was still increasing but at a decreasing rate. Large incremental changes in the

overall lake water quality caused by implemented conservation practices were not measured within the four year monitoring period. This was because of the high degree of inherent variability within the watershed system and the long response time of the ecosystem to subtle changes in land use. The project observed several changes in water quality parameters associated with the three periods of land management. In general, lake water quality reflects the interaction of land management and precipitation. Lake water quality is at its poorest during period one (fertilizer and seedbed establishment) with excess rainfall and at its best during period three (plant residues) with no rainfall.

19. Incentives:

a. Cost Share Rate: not reported

b. $ Limitations: not reported

c. Assistance Programs: Information and education programs led to 18% of the cropland in the project area being treated without direct financial assistance. An intensive effort to make one-on-one personal contacts with landowners was found to be very effective.

III. Lessons Learned: (ref. 11)

Nonpoint source pollutants have greater impact on lakes than streams because of the hydraulic differences between these two water resource systems.

The USLE alone is not adequate to measure sediment yield or to predict sediment movement off individual fields. Additional modeling or calculations are needed to determine sediment delivery to the water resource.

Treating designated critical acres has a greater impact on reducing soil erosion than treating randomly selected acres.

Over 80% of the annual sediment load was transported during 5% of the time.

IV. Project Documents

1. Davenport, T.E. and J.J. Oehme. 1982. Soil Erosion and Sediment Delivery in the Blue Creek Watershed, Pike County, Illinois. IEPA/WPC/82-002.

2. Davenport, T.E. 1982. Economic and Physical Impacts on Individual Farm Management Units Under Alternative Management Scenarios in the Blue Creek Watershed, Pike County, Illinois. IEPA/WPC/82-005.

3. Davenport, T.E. 1981. Blue Creek Watershed Project, Pike County, Illinois (May 1979 - October 1980). 64pp.

4. Davenport, T.E. 1983. Soil Erosion and Sediment Transport Dynamics on the Blue Creek Watershed, Pike County, Illinois. IEPA/WPC/83-004. Illinois EPA, Springfield, Illinois. 212pp.

5. Davenport, T.E. 1982. Comparative Evaluation of Gross Erosion Assessment Techniques Used in the Blue Creek Watershed, Pike County, Illinois. Illinois EPA, Springfield, Illinois. 39pp.

6. Davenport, T.E. and J.J. Oehme. 1982. Soil Erosion and Sediment Delivery in the Blue Creek Watershed, Pike County, Illinois. Preliminary Analysis. Illinois EPA, Springfield, Illinois. 35pp.

7. Davenport, T.E. 1982. Water Resource Data and Preliminary Trend Analysis for the Blue Creek Watershed Project, Pike County, Illinois. Phase I. IEPA/WPC/82-001. Illinois EPA, Springfield, Illinois. 109pp.

8. Davenport, T.E., et al. 1982. Water Resource Data and Preliminary Trend Analysis for the Blue Creek Watershed Project, Pike County, Illinois. Phase II. IEPA/WPC/82-008. Illinois EPA, Springfield, Illinois. 161pp.

9. Davenport, T.E. 1983. Water Resource Data and Trend Analysis for the Blue Creek Watershed Project, Pike County, Illinois. Phase III. IEPA/WPC/83-003. Illinois EPA, Springfield, Illinois. 264pp.

10. Lee, M.T., P. Makowski and W. Fitzpatrick. 1983. Assessment of Erosion, Sedimentation, and Water Quality in the Blue Creek Watershed, Pike County, Illinois. SWS Contract Report 321. Surface Water Section, Illinois State Water Survey, Champaign, Illinois. 191pp.

11. Illinois Environmental Protection Agency. 1984. Blue Creek Watershed Project Executive Summary and Recommendations. IEPA/WPC/84-008. Springfield, Illinois. 31pp.

12. Davenport, T.E. 1983. Comprehensive Monitoring and Evaluation of the Blue Creek Watershed.

V. NWQEP Project Contact

Tom Davenport
Nonpoint Source Coordinator
USEPA Region V
Water Quality Section (WQS-TUB-08)
230 S. Dearborn
Chicago, Illinois 60604
tel. (312) 886-0148

LaPlatte River Watershed

Chittendon County, Vermont
MLRA: R-142
H.U.C. 020100-03

I. Major Contributions Toward Understanding the Effectiveness of NPS Control Efforts

This project will contribute knowledge on the effectiveness of manure management (timing and type of spreading on fields) and practices to control barnyard and milkhouse waste runoff. The project found the CREAMS model inadequate for simulating pollutant losses under northern United States climatic conditions. The project also contributed to the verification, calibration and modification of four Vermont SCS models that calculate phosphorus and sediment concentrations in cropland erosion runoff, and phosphorus in barnyard runoff, milkhouse effluents and manure stacks runoff.

II. Project Characteristics and Results

1. **Project Type:** PL83-566 (USDA - SCS)

2. **Timeframe:** 1979 - 1990

3. **Total Project Budget** (excludes water quality monitoring funds and farmers' contributions): not available

4. **Cost Share Budget:**
   a. Funds Allocated: $680,507 (as of August 1987)
   b. Farmers' Contributions: $292,842 (estimated)

5. **Water Quality Monitoring Budget:** $1,236,942 (ref. 2, p. H-29)

6. **Watershed Area:** 34,137 acres

7. **Project Area:** 34,137 acres

8. **Critical Area:** none designated

9. **Land Use of Monitored Project Area:** Monitored area is 25,981 acres, 76% of the project area.

Use	% monitored area
agriculture	51
cropland	~24
pasture	~27
woodland	39
urban/roads	8
other	2

There are 50 active farming operations in the project area.

10. **Animal Operations in Project Area:**
    a. Dairy: 35 farms with a total of 3,999 a.u.
    b. Beef: 2 farms
    c. Horse: 1 farm
    d. Sheep: 1 farm

The Federal Dairy Termination Program (1985) and other livestock sales resulted in a net decrease in total animal units of over 25% in less than 2 years.

11. Water Resource Type: LaPlatte River and tributary streams flowing into Shelburne Bay of Lake Champlain.

12. Water Uses and Impairments:
Boating and aesthetics in Shelburne Bay and the LaPlatte River are impaired by phosphorus and sediment.

13. Water Quality at Start of Project: (Meals, 1985, personal communication)

Year 2 Data: Oct. 1979 - Sept. 1980

	Station 1 (~67% of watershed)			Station 2 (~12% of watershed)		
	mg/l					
Parameter	min	max	median	min	max	median
TSS	1.16	4.8	8.95	2.97	8.3	15.5
TP	0.113	1.406	0.327	0.023	0.424	0.90
TKN	0.47	3.52	1.02	0.07	3.35	0.79

14. Meteorologic and Hydrologic Factors:
a. Mean Annual Precipitation: 33.7 inches
b. USLE 'R' Factor: ~90

15. Water Quality Monitoring Program:
a. Timeframe: 1979 - 1990
b. Sampling Scheme:
1. Location and Number of Monitoring Stations; Frequency, and Sample Type:
a) Three stream stations monitor small subbasins and a fourth monitors ~67% of the watershed. Sites are automatically sampled every 8 hours and usually analyzed as 24-or 72-hour composites, except during periods of high flow when samples are composited over shorter intervals.
b) The effluent of a sewage treatment plant in the watershed is automatically sampled as one 7-day composite analyzed each month; two grab samples per month are analyzed for bacteria.
c) Pollutants Analyzed: OP, TP, TSS, VSS, turbidity, TKN, NH_3, nitrate, DO and bacteria
d. Flow Measurements: continuous stage recorders
e. Other:
1. Precipitation measured by 3 gages in the watershed.
2. Temperature, pH, and conductivity measured.
3. Special projects: There are several special studies that add to the scope of this project: 1) a paired watershed study to document the field-scale effects of best manure management; 2) a study to determine the effectiveness of practices dealing with barnyards and milkhouses; 3) phosphorus attenuation in the LaPlatte River downstream from a sewage treatment plant; 4) verification of the model CREAMS; and 5) monitoring changes in stream biota.

16. Critical Areas:
This project started prior to the RCWP, therefore, it had no requirement that critical areas be determined and no strong precedent or criteria existed for defining critical areas. The project did identify critical areas or prioritize individual farms for treatment. The project reports has estimated the number of acres contributing nutrient and sediment loads as determined by models (ref. 11, p.25). Location of these acres is not reported.

17. Best Management Practices:
a. General Scheme: The practices most emphasized in this project are animal waste management (manure storage, barnyard and milkhouse waste treatment). Other practices contracted and

implemented include conservation cropping, permanent vegetation, changes in crop rotation, contouring, and streambank erosion control.

b. Quantified Implementation Goals: Implementation goals include the development of 412 conservation plans to treat: (1) 2,640 acres of cropland, grassland, and forestland, (2) 30 animal waste systems, and (3) protection of 2,500 feet of critically eroding streambank (ref. 1).
c. Quantified Contracting/Implementation Achievements: (ref. 11, p.19)

Location	% contracted	% implemented
project area	19	95
project area farms	54	85

Over half of the contracts have expired, however, there is no indication that farmers have abandoned their BMPs.
d. Effectiveness of BMPs: Manure storage facilities treat over 48,000 tons of manure annually. Cropland erosion control practices reduce soil erosion by an average of 2,100 tons per year, as estimated using the USLE. Streambank erosion controls have reduced channel erosion and sedimentation by about 450 tons annually.
Preliminary results from studies on the effectiveness of barnyard and milkhouse runoff management follow:

Milkhouse Waste Study: A filter strip reduced concentrations of TSS, TP and TKN in surface flow 92, 86 and 79%, respectively. Concentrations of TSS, TP and TKN in localized groundwater were reduced 93, 92 and 91%, respectively. An effluent drainage ditch retained inputs of P and N during periods of normal to low flow. A ditch of this type however, may become a source of nutrients and sediments during periods of high flow.
Barnyard Runoff Study: The filter strip performed poorly due to channelized surface flow and a high hydraulic loading rate. If paved livestock yards are not scraped frequently, runoff from these yards contains significantly more sediment and nutrient than runoff from unpaved barnyards.
Manure Application to Hayland: This study used a paired watershed design to monitor the water quality effects of winter spreading of manure as opposed to storing manure in winter for application and incorporation in the fall. Fall application reduced SS concentrations but increased P concentrations and discharge. Winter application increased P concentrations, decreased discharge, and did not change SS concentrations. From manure applied in winter, 5% P was lost in runoff following. Only 2% was lost from fall application.

18. Water Quality Changes:

Higher precipitation and streamflow in year 8 made interpretation of long-term water quality trends difficult. In watersheds 1, 2 and 3, concentration and yield of sediment and nutrients were higher than in the previous year, but generally lower than in other years of high flow.

A trend of decreasing N concentrations and export continued in year 8. Concentration and yield of all P forms appears to be increasing on a long-term basis. A similar trend may be developing for sediment.

19. Incentives:

a. Cost Share Rates: 75% - agricultural waste management (including storage facilities) and streambank protection.
60% - waterways, livestock exclusion, and pasture and hayland planting.
50% - diversions and troughs for pasture management.
b. $ Limitations: A maximum of $30,000 per treatment type (BMP) was allowed.
c. Assistance Programs: None have been reported other than the technical assistance of SCS for installing practices.
d. Other Incentives or Regulations: None have been reported. There have, however, been some ACP funds used for conservation practices, within the watershed, mostly prior to this project.

III. Lessons Learned

The high variability of meteorologic and hydrologic factors makes it difficult to establish significant trends in water quality. The model CREAMS was found to be inadequate for predicting runoff, sediment and phosphorus export from two field sites. The project recommended that the model be modified and/or carefully fitted with observed data to yield more accurate estimations of export under winter conditions in the northern United States.

Project staff have noted that changes in project area land use may be related to observed localized water quality trends. In one subwatershed, declining corn acreage and manure application may be related to an observed decreasing trend in P and N concentration and yield from that area. Increasing corn acreage and manure application in another subwatershed may be related to observed increases in sediment and nutrient export. Careful tracking of land use changes is important in the overall project effort.

IV. Project Documents

1. Watershed Plan for LaPlatte River Watershed Vermont, 1979. Chittenden County, Vermont. 101 pp.

2. Cassell, E.A. and D.W. Meals, Jr., 1981. LaPlatte River Watershed Project Water Quality Monitoring and Analysis Program, Program Report No. 1, Description of Watershed and Water Quality Program. Vermont Water Resources Research Center, University of Vermont.

3. Cassell, E.A. and D.W. Meals, Jr., 1981. LaPlatte River Watershed Project Water Quality Monitoring and Analysis Program, Program Report No. 2, Program Achievement Report - Year 1. Vermont Water Resources Research Center, University of Vermont.

4. LaBar, G.W., 1982. LaPlatte River Fisheries/Benthos Evaluation Phase I 1980-1981 Final Report. University of Vermont. 40pp.

5. Clausen, J.C., D.W. Meals, E.A. Cassell, 1983. Supplement to the Program of Work, Water Quality Monitoring and Analysis, February 1979. Vermont Water Resources Research Center. University of Vermont. 14pp.

6. Meals, D.W. Jr., 1983. LaPlatte River Waterhsed Water Quality Monitoring and Analysis Program Report No. 5, Year 4, 1981-1982, Executive Summary. Vermont Water Resources Research Center, University of Vermont. 25pp.

7. Meals, D.W. Jr., 1983. LaPlatte River Watershed Water Quality Monitoring and Analysis Program, Program Report No. 5, Year 4, 1981-1982. Vermont Water Resources Research Center, University of Vermont. 160pp.

8. Meals, D.W. Jr., 1984. LaPlatte River Watershed Water Quality Monitoring and Analysis Program, Program Report No. 6, Year 5, 1982-1983. Vermont Water Resources Research Center, University of Vermont. 133pp.

9. Meals, D.W. Jr., 1985. LaPlatte River Watershed Water Quality Monitoring and Analysis Program, Program Report No. 7, Project Year 6, 1983-1984. Vermont Water Resources Research Center, University of Vermont. 133pp.

10. Meals, D.W. Jr., 1986. LaPlatte River Watershed Water Quality Monitoring and Analysis Program, Program Report No. 8, Project Year 7, 1984-1985. Vermont Water Resources Research Center, University of Vermont. 154pp.

11. Meals, D.W. Jr., 1987. LaPlatte River Watershed Water Quality Monitoring and Analysis Program, Program Report No. 9, Project Year 8, 1985-1986. 228pp.

V. NWQEP Project Contact

Don Meals
Vermont Water Resources Research Center
School of Natural Resources
University of Vermont
Burlington, VT 05401-0088
Telephone (802) 656-4057

Chapter Three Project Analysis

Saline Valley RCWP, Michigan

Agricultural Setting and Water Resource Problem

The Saline Valley RCWP project is located in southeastern Michigan in Washtenaw and Monroe Counties. It includes 76,660 acres, about 70% of which is intensively cropped mostly in corn and soybeans. In addition, there are about 9,500 animal units in the project area.

Saline River and Macon Creek which drain the project area have been identified as disproportionate contributors of phosphorus, on the basis of area, to the western basin of Lake Erie. The 42,400 critical acres have an average erosion rate of 7.2 tons per acre per year, and total phosphorus loading is estimated at 40 tons per year: 23 tons from commercial fertilizer and 16 tons from animal waste. Two sewage treatment plants for the towns of Saline and Milan are major phosphorus contributors in the project area.

Water Quality Monitoring Design

The water quality monitoring design is very efficient and straightforward. Weekly grab samples have been taken at seven stream sites without interruption since 1981. Each sample includes an instantaneous stream flow measurement. The parameters measured include suspended solids, soluble reactive phosphorus, total phosphorus, ammonia, nitrate, silica, pH, and conductivity.

Analysis of Water Quality Data: Preliminary Results

Although not all BMPs contracted under RCWP are installed, significant changes in farm management have occurred in the watershed, and sufficient time has elapsed that it is plausible that water quality changes due to BMPs could be occurring. The remainder of this section is a critical examination of the water quality data drawing from a water quality report developed by the project (Johengen, 1987).

The locations of the monitoring stations are shown in Figure 3.1. Stations 3-8 are in the Saline River drainage although only stations 5 and 8 are actually on the Saline River. Station 9 is on Macon Creek.

Cursory analysis of the water quality data reveals that the majority of phosphorus loading from this project area is not from agricultural nonpoint sources, but rather from the combination of urban nonpoint sources and point sources. This is evidenced by the fact that each

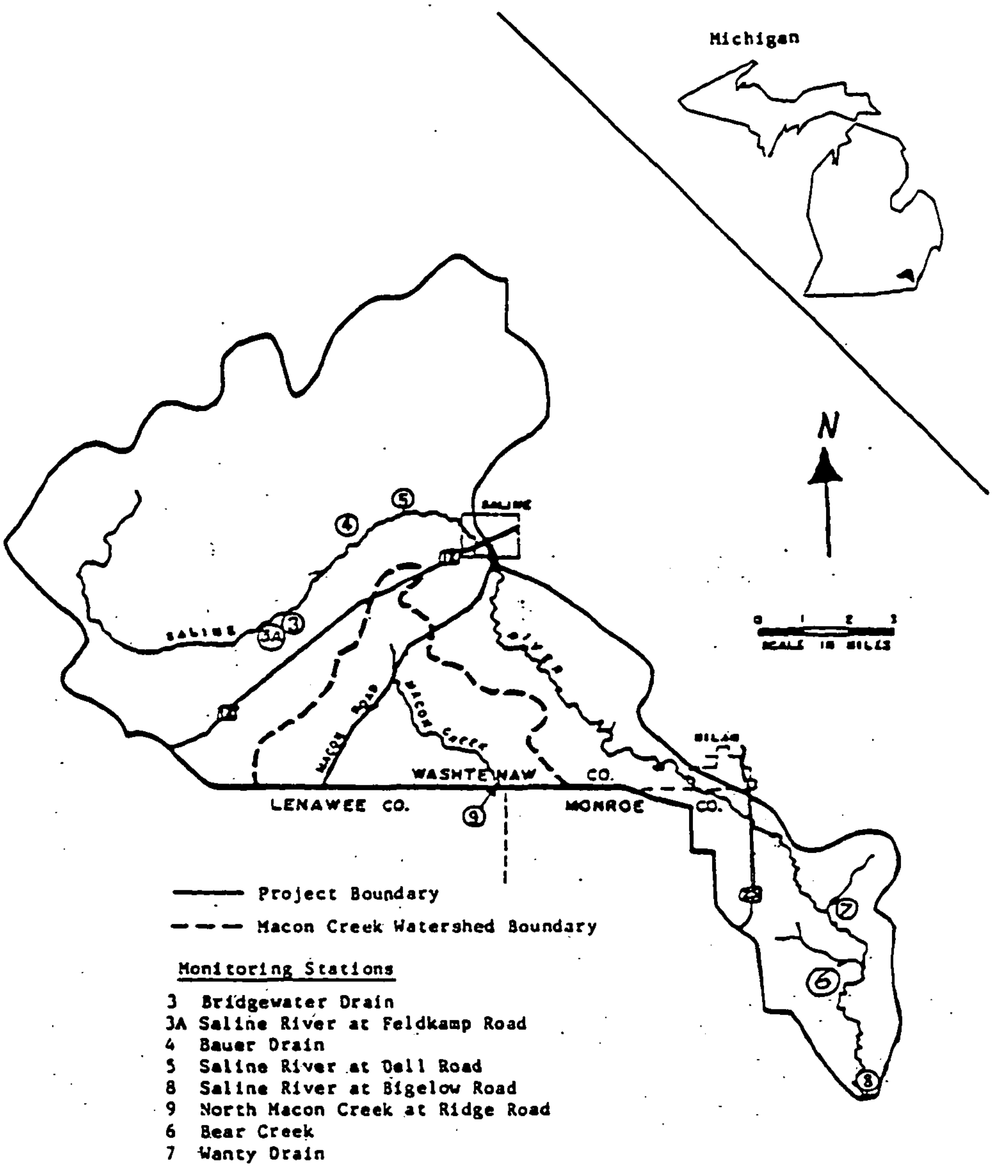


Figure 3.1 Saline Valley RCWP Project Area Map (after Johengen, 1987).

monitored agricultural subbasin to the Saline River shows much lower P concentrations than station 8 on the Saline River below the outfalls of the Milan and Saline sewage treatment plants. Station 5 on the Saline River above Milan and Saline also shows low P concentrations relative to station 8. Table 3.1 shows that total P concentrations at station 8 decrease during high flow periods (indicative of point sources) while all other stations show significant con-

Table 3.1 Comparison of Total Phosphorus Concentrations (mean TP not flow weighted) at Upstream Tributaries (stations 3,4,5,6,7) with the Watershed Outlet (station 8). (Data from 6/30/83 to 6/30/84).

Station 8 flow rate (m^3/sec)	n	[TP] (mg/l) contributed from NPS upstream (stations 3,4,5,6,7)	[TP] (mg/l) at watershed outlet (station 8)	Loading contribution from upstream NPS
Low <5.0	30	45.3	387	12%
High >5.0	9	84.5	214	40%

centration increases during high flow (indicative of nonpoint sources). The data suggest that point sources are the major P source in both low flow and high flow periods.

Two important implications of these results are:

1. International Joint Commission P loading reduction goals (30%) for this watershed require point source P removal and NPS control.

2. Even in a predominantly agricultural watershed, small domestic sewage water treatment plants, if present, are likely to be the main source of phosphorus.In this case, the towns of Milan and Saline have a combined sewered population of less than 6,000, yet sewage effluent-P outweighs P from nonpoint sources.

The project has done a considerable amount of analysis of the water quality data (Holland et. al., 1985; Johengen, 1987). Johengen (1987) focused on comparing pollutant loads between different years and different stations. Loads for stations 3, 4, 5, 6, and 7 were normalized to a mean annual discharge given by the following equation:

Normalized Load = (Annual Load/Annual Discharge) x Mean Annual Discharge

It should be noted that loads calculated by this procedure are subject to bias because both concentration and discharge estimates are based on random weekly grab samples.

The goal of this experimental design is to observe significant changes in pollutant loads between years and stations. Differences were tested for significance using one-way analysis of variance except when the data failed to meet assumptions of normality or homogeneity in which case nonparametric methods such as the Krushkal-Wallis procedure and Scheffe's multiple comparison tests were used.

Figures 3.2-3.5 show yearly loading time trends for various pollutants at the five stations analyzed (Johengen, 1987). As shown in Figure 3.2, there was a substantial decrease in suspended solids loadings in years 2 through 4 at stations 4 and 6 and an increase in year 5. Stations 3 and 5 followed the same pattern except that both stations showed a dramatic increase in year 3. The cause of the annual variations is unknown since the land use data are not currently organized by subbasins. Some of the variotion in loading may be attributable to variation in runoff. Analysis of concentration data considering instantaneous discharge as covariate may reveal a different picture.

The overall trend for total P (Figure 3.3) is similar to suspended sediment but with less increase at station 3 during year 3. Johengen (1987) hypothesizes that BMPs improved water quality in years 2-4 but lost their effectiveness in year 5. Given experiences with BMPs such as animal waste management and conservation tillage in other RCWP projects, this seems unlikely.

The soluble reactive phosphorus (SRP) data (Figure 3.4) show the same 'U'- shaped pattern with only a peak in year 3 for station 6. This suggests that the total P peak in year 3 for

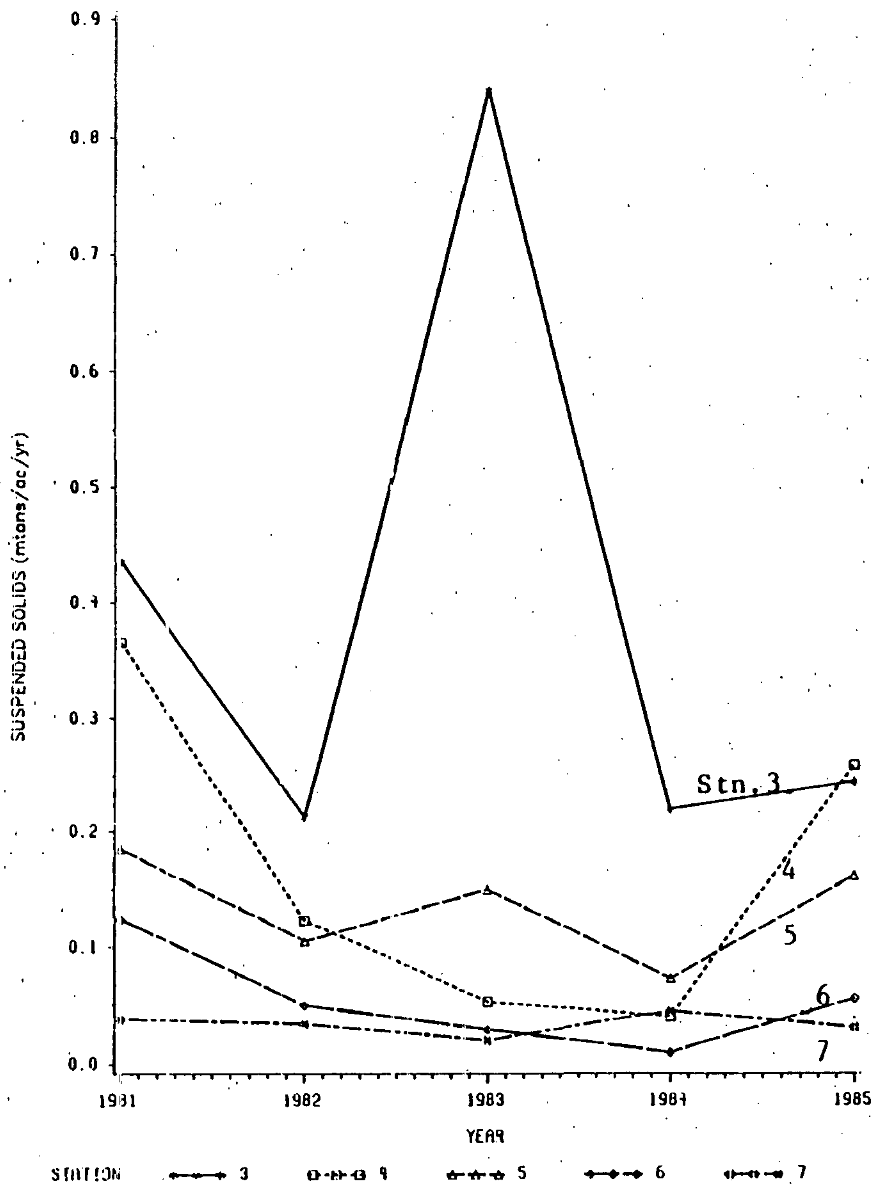


Figure 3.2 Discharge Normalized, Unit Areal Loadings for Suspended Solids (Johengen, 1987).

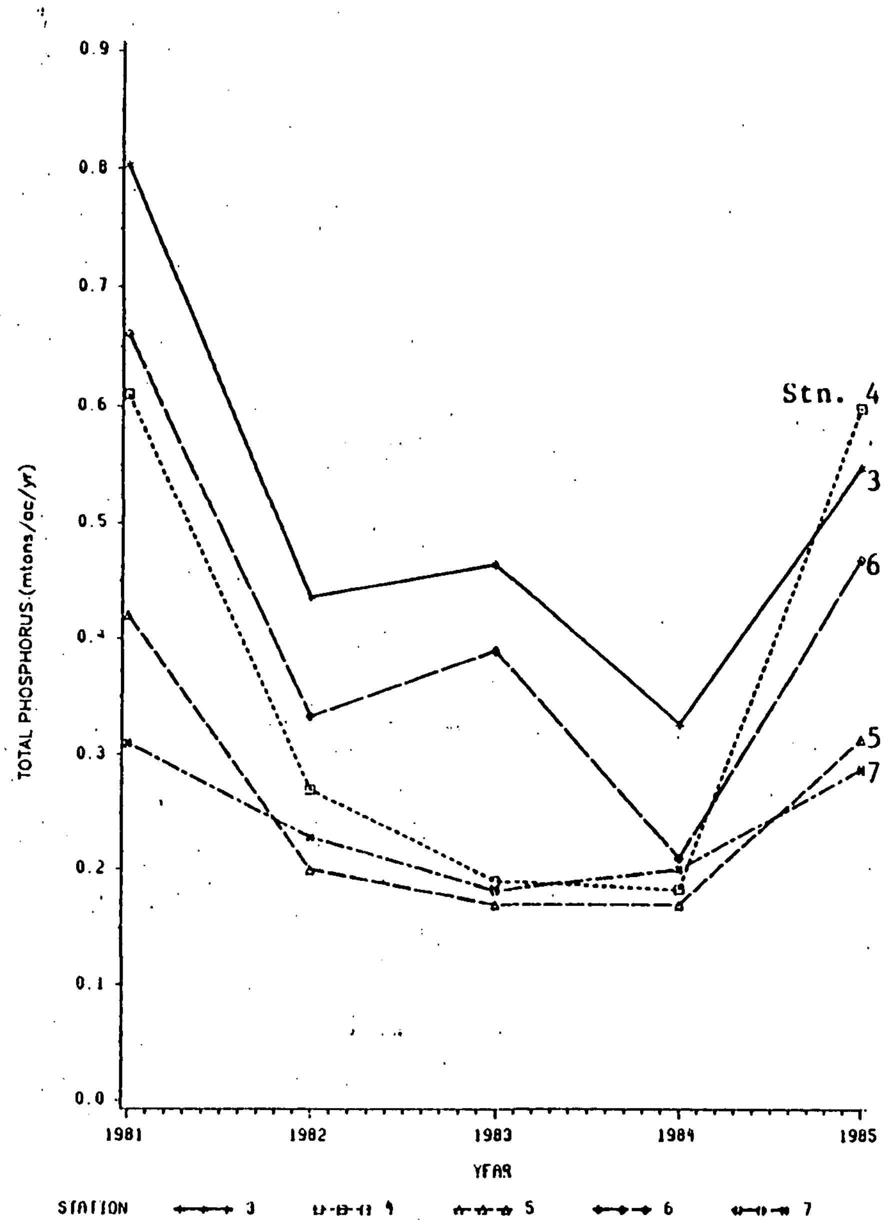


Figure 3.3 Discharge Normalized, Unit Areal Loadings for Total Phosphorus (Johengen, 1987).

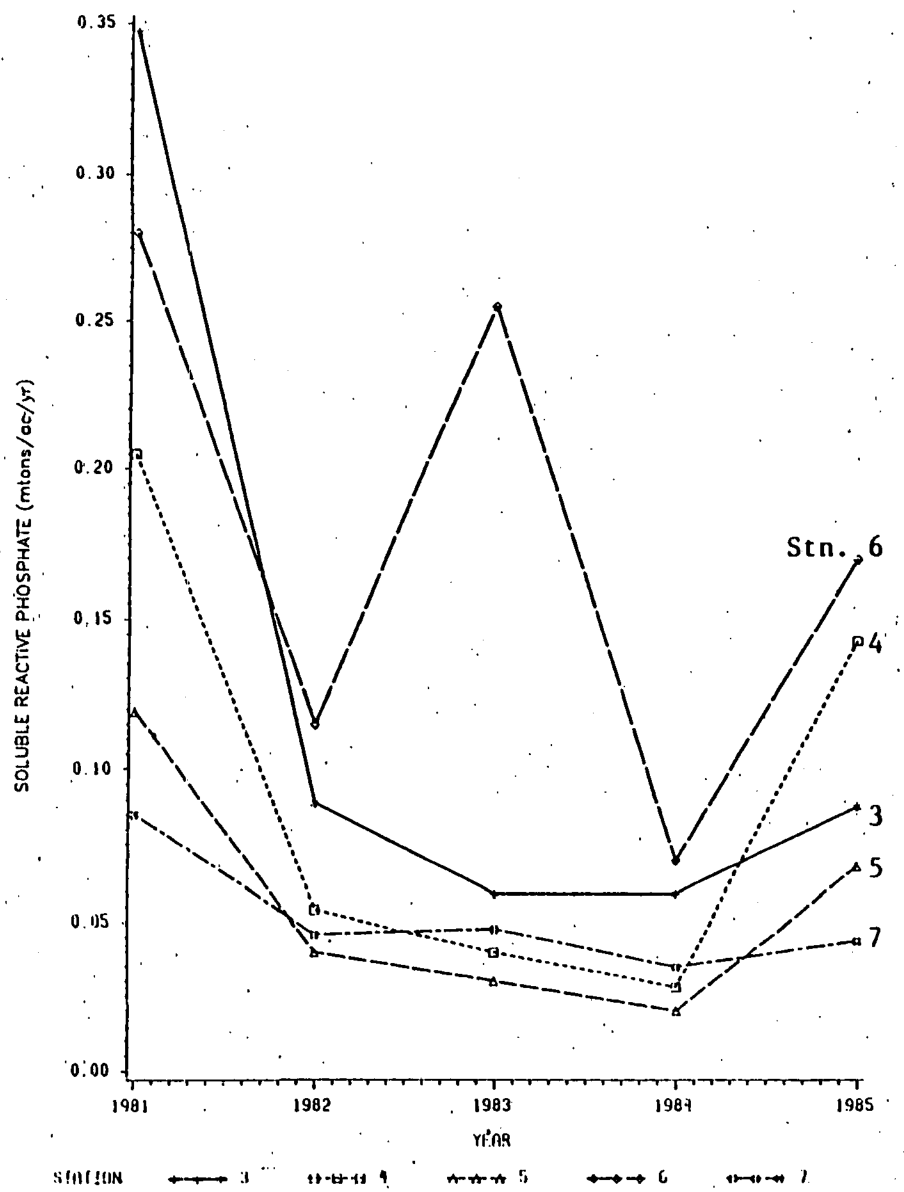


Figure 3.4 Discharge Normalized, Unit Areal Loadings for Soluble Reactive Phosphorus (Johengen, 1987).

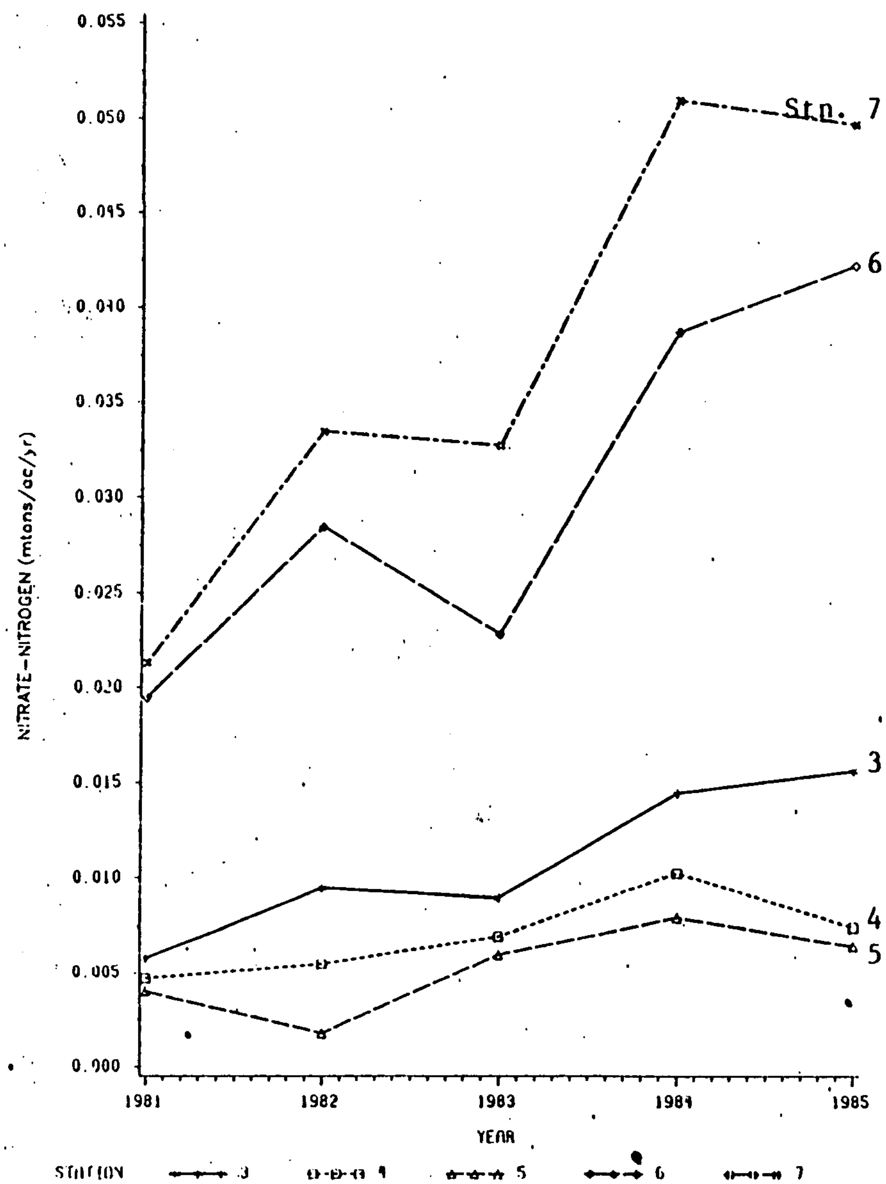


Figure 3.5 Discharge Normalized, Unit Areal Loadings for Nitrate-Nitrogen (Johengen, 1987).

station 6 was almost entirely dissolved phosphorus because no increase occurred in suspended solids to account for the change.

Nitrate loading shows a very different pattern than the other pollutants (Figure 3.5). There was an overall increase in loadings at all stations over the five years. Also in direct contrast to the other pollutants, year 3 is the only year in which there was some decrease in nitrate loading. Note that stations 6 and 7 show the highest nitrate loads (Figure 3.5) and the lowest suspended solids loads (Figure 3.2). One explanation is that the BMPs being employed are only effective in controlling surface losses of pollutants and actually enhance the transport of leachable pollutants such as nitrate through subsurface flow. More water quality data and better land use data are required for a more definitive analysis.

It should also be noted in Figure 3.5 that the unit areal nitrate loadings reported for stations 6 and 7, about 40 to 100 pounds per acre, are some of the highest reported for an agricultural watershed. For instance, the total N loadings from the Little Conestoga River watershed in Pennsylvania, with over 2 animal units per acre combined with excessive fertilizer applications, is estimated at 44 pounds per acre. The other stations in the Saline River project area show more typical agricultural loading rates of 4 to 30 pounds per acre per year. These high values should be checked.

As more BMPs are installed in the project and a more complete post-BMP water quality data base is developed, it should be possible to detect potential water quality changes with greater sensitivity and tie them to land treatment activities.

LITERATURE CITED

Holland, R.E., A.M. Beeton, and D. Conley. 1985. Saline Valley Rural Clean Water Project Interim Report on Monitoring. Michigan Sea Grant College Program, Great Lakes and Marine Water Center.

Johengen, T.H. 1987. Documenting the Effectiveness of Best Management Practices to Reduce Agricultural Non-Point Source Pollution. Unpublished research paper to fulfill requirements at the University of Michigan, Ann Arbor, Michigan.

Chapter Four Project Analysis

Prairie Rose Lake RCWP, Iowa

ABSTRACT

The Prairie Rose Lake RCWP is located in west central Iowa. The 4,568 acre watershed includes a 215 acre impoundment, Prairie Rose Lake, and 3,648 acres of cropland. Use of the lake is impaired by excessive sedimentation, turbidity, and eutrophic conditions. Agricultural runoff is the primary source of sediment and nutrient loadings to the lake. The primary BMPs are terracing and nutrient management; contracts have been made to treat 83 percent of the critical area. As of September 30, 1986, eighty-nine percent of the contracts were installed and 74 percent of the critical acreage were considered treated. The watershed is small and land use is homogeneous. The project should be able to document water quality changes at the impaired resource within the 10-year RCWP timeframe because it has consistent monitoring of lake water quality and a large treated area.

Persistent turbidity after precipitation noted by project personnel prior to the RCWP is thought to have decreased since RCWP began. However, this visual observation is not easily evaluated. Bathymetric mapping indicates that the rate of lake sedimentation may have decreased. The majority of BMP implementation under RCWP occurred in 1982. The project estimates that the sediment delivered to the lake had been reduced 48% by the end of 1982. The project hypothesizes that reduction in sediment loads stimulated algal growth by increasing light penetration.

Analysis of covariance, with adjustment for precipitation and chlorophyll *a*, shows that lake water clarity was greatest during 1982 and 1983, shortly after the start of RCWP. In subsequent years, however, water clarity has declined to 1981 levels.

Results of our analysis confirm some tradeoff of sediment turbidity for algal turbidity. A precipitation covariate explained 6% of the variability in Secchi depth measurements. Even with adjustment for precipitation, statistical analysis of water clarity parameters (Secchi depth, turbidity) suggested that water quality is deteriorating over time. Adjustment for chlorophyll *a* explained an additional 26% of Secchi depth variability. After correcting for both precipitation and chlorophyll *a* there is no significant trend over time, neither improving nor deteriorating, in water clarity data.

In light of the above results, we offer two possible explanations for the relatively high turbidity levels from 1984 through 1986:

- Unrecognized factors may be masking the expected improvement in water clarity. Such factors may include resuspension of bottom sediments or other parameters not measured.
- Fine sediment delivered to the lake has not been reduced to the extent estimated by the project. The effectiveness of BMPs may have been overestimated and/or the sediment delivery ratio may be greater than the estimated 0.32. Terracing may not be controlling erosion of fine soil particles which cause turbid conditions when resuspended in the lake.

Considering the variability observed to date, the lake monitoring scheme should be able to document a real change of approximately 20 percent in water clarity as measured by Secchi depth and surface turbidity with ten years of monitoring.

INTRODUCTION

Background

Prairie Rose Lake is located in Shelby County in west central Iowa. Its watershed covers 4,568 acres, including the 215 acre impoundment surrounded by 433 acres of state parkland. The project area eligible for land treatment covers 3,920 acres, primarily cropland (3,648 acres) with highly erosive soils. The lake was constructed in 1962 and is a popular water resource for fishing, swimming, and boating. Drinking water for park visitors is drawn from the lake.

When the RCWP project began the lake was impaired by excessive sedimentation, turbidity, and eutrophic conditions. Sedimentation impaired lake storage volume and game fish habitat. Turbidity and algal growth impaired swimming.

Pollution sources within the park have been treated adequately with the park's sewage treatment facilities, permanent vegetation, and shoreline erosion control practices. Tributary monitoring and erosion estimates have confirmed that agricultural land surrounding the park is the primary source of sediment and nutrient loadings. Pesticides in agricultural runoff are also a concern. Before RCWP, an estimated 62% of the cropland was eroding at an average rate of 30 tons per acre. Most of the cropland is planted in either continuous corn or corn-soybean rotations regardless of field slope.

Project Perspectives

The following questions can be addressed by analyzing this project's water quality and BMP implementation data. Analyses and discussion in this chapter address the first three of these issues.

1. Can the project document a decrease in suspended sediment concentration or a decrease in sedimentation rate in Prairie Rose Lake? If significant decreasing trends exist, can the project relate them directly to BMP implementation, specifically terracing and conservation tillage under the RCWP? This is a small watershed with homogeneous land use and high BMP implementation, and it should be a good setting to yield answers to these questions.

2. Can adjustment variables (e.g., precipitation, chl *a*, and TP) be used to correct for some of the measured variations in pollutant concentrations?

3. If water quality trends exist in the lake, how long should monitoring be required to document them? An important aspect of the RCWP experiment is to determine if improvements in water quality can be measured directly at the impaired resource. A long monitoring timeframe may be required due to the complex hydrology of lakes.

4. Is terracing the most cost-effective BMP for reducing sediment delivered to Prairie Rose Lake that this project could have implemented?

Land Treatment Strategy

The eligible project area (entire watershed excluding parkland and lake) was identified as critical area (3,920 acres) for land treatment under RCWP (Figure 4.1). Cropland covers 79% of the project area. Major project goals are to control excessive soil erosion on at least 80% of the critical area and to reduce the rate of sediment delivery to the lake by 60%. A sediment delivery ratio of 0.32 is assumed by the project (Progress Report, 1986). Achievement of goals would reduce annual nutrient loadings by 59,290 lbs. of phosphorus and 149,270 lbs. of nitrogen per year. The BMPs are primarily terracing and nutrient management.

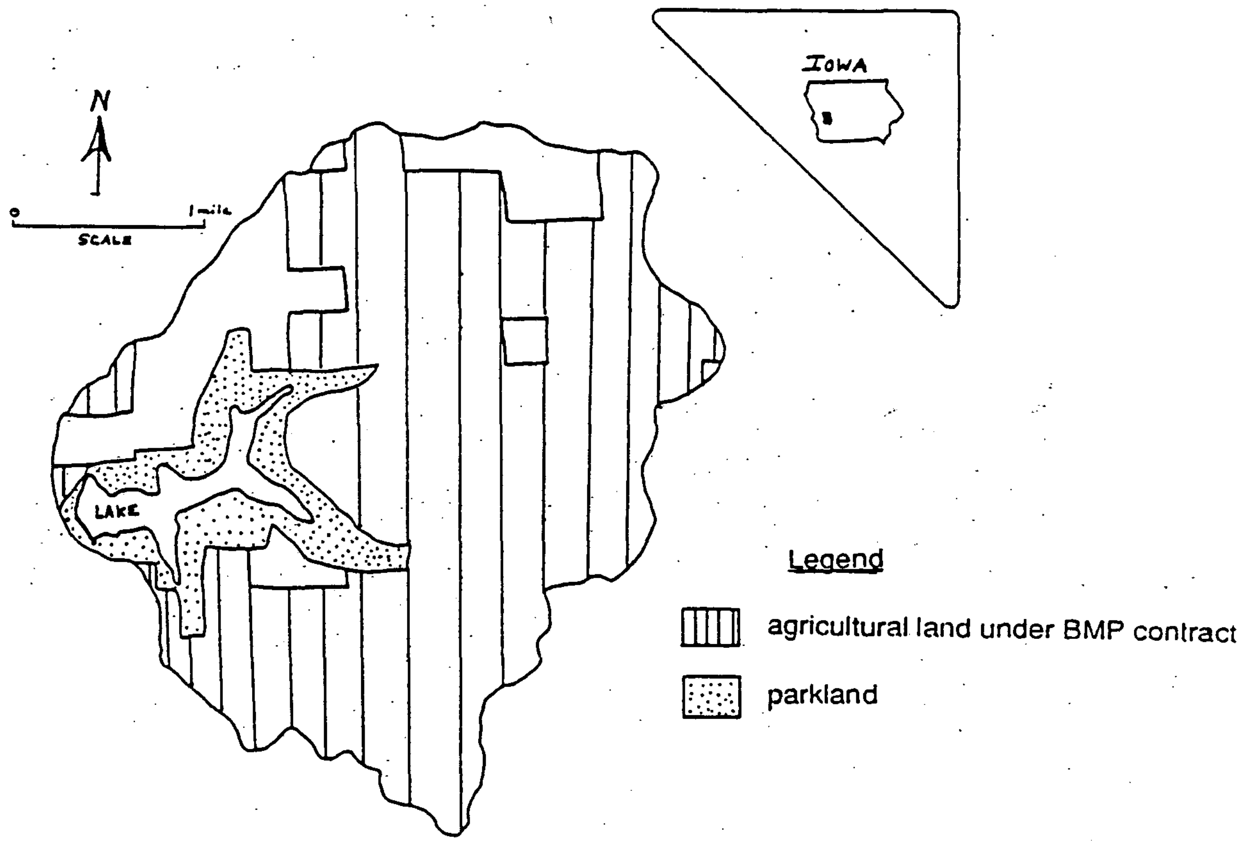


Figure 4.1 Prairie Rose Lake RCWP, Shelby County, Iowa (after Monitoring Report, 1986).

Water Quality Monitoring Strategy

RCWP monitoring began in 1981. Biweekly grab samples are taken at three locations (Figure 4.2) in the lake -- site 1 (the upper reach), site 2 (mid-lake), and site 3 (the deepest point near the dam). Surface and bottom samples are taken at each location. The depths of bottom samples for sites 1, 2, and 3 are 8, 11, and 24 feet, respectively. Grab sampling is conducted from May through September, yielding 10 samples per year per site. Parameters analyzed are Secchi depth, turbidity, chlorophyll-*a* (chl *a*), fecal coliform (FC), total phosphate

(TP), orthophosphate (OP), nitrate- nitrogen (NO_3-N), and ammonia plus ammonium-nitrogen ($NH_3 + NH_4$).

Samples are also taken at the drinking water intake within 24 hours of each event greater than 2 inches of precipitation. These samples are analyzed for concentrations of pesticides and heavy metals. Surface water samples are taken near the swimming beach 24 and 48 hours after all events (maximum of 7 events) of greater than 1 inch of precipitation. These samples are analyzed for fecal coliform bacteria levels. Analyses of bottom sediment and fish are also part of the monitoring program. Bathymetric mapping of the lake bottom profile was performed in 1971, 1980, and 1986. A final survey will be made in 1991.

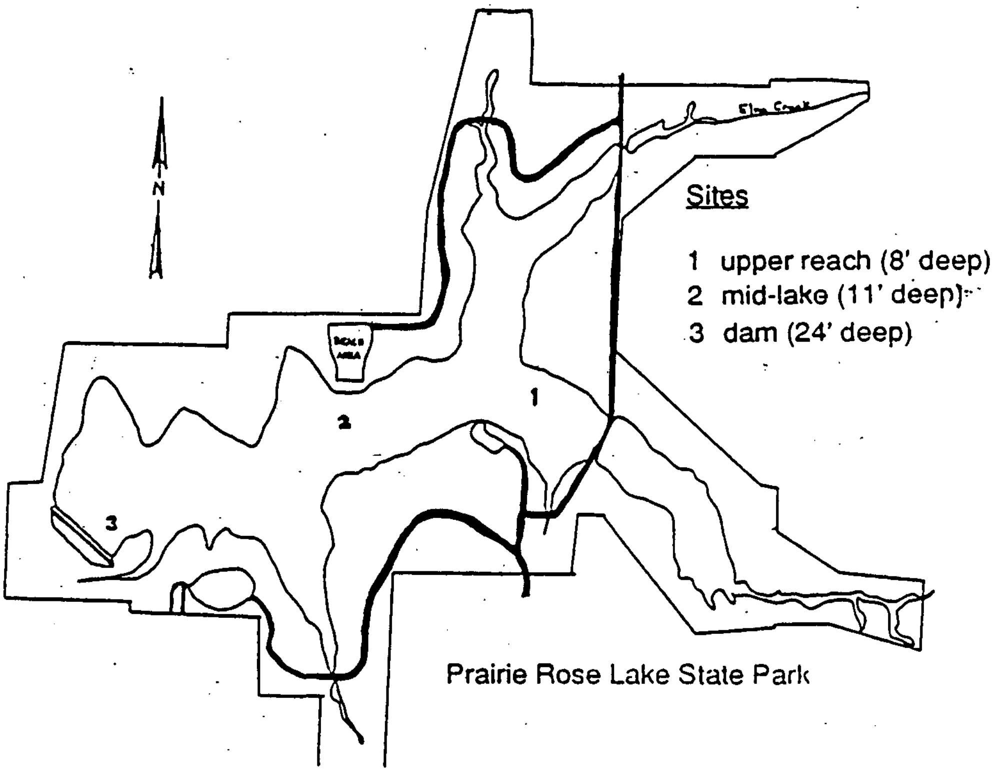


Figure 4.2 Prairie Rose Lake RCWP Monitoring Sites (after Monitoring Report, 1986).

BMP Implementation Achievements

Several BMPs were installed under other cost share programs prior to the RCWP. These practices included contour farming on 1,000 acres, grassed backslope terraces protecting 528 acres, and two sediment control structures. The number of soil conservation practices implemented increased substantially with financial incentives offered under the RCWP project.

The project was well received by landowners, and contracting for BMP implementation progressed quickly. By September 1983, 75% of the critical area was under contract. The project estimates that, as of September 1986, soil losses were reduced 62% from 80,800 to 30,900 tons per year. Assuming a delivery ratio of 0.32, sediment delivered to the lake was estimated to have been reduced, from 26,300 to 9,900 tons (Progress Report, 1986). Most of this reduction was attributed to BMP installation in 1982.

Contracting was completed in 1985, bringing the total critical acres under contract to 3,239, or 83% of the critical area (Table 4.1). Seventy-four percent of the critical area is considered treated (2,900 acres). The project estimates that the majority of cropland not under conservation tillage is farmed using some form of reduced tillage.

Table 4.1 BMP Installation in Prairie Rose Lake RCWP as of October 1986 (Progress Report, 1986).

BMP No.	Description	Units Installed
1	pasture seeding	32 acres
4	terraces	50.3 miles affecting 1,760 acres
7	waterway systems	10.1 acres
9	conservation tillage	560 acres
12	sediment control structures	13 structures under RCWP
15-16	fertilizer & nutrient management	10 farms affecting 828 acres

Commodity control programs which offer annual financial incentives to set aside corn land have had a significant effect on land use within the project area. In 1983, about 20% of the total cropland in the project area was set aside under the Federal Payment In Kind (PIK) program. Corn set aside data for years in which RCWP has been active are listed in Table 4.2.

Table 4.2 Corn Acreage Within the Prairie Rose Lake RCWP Set Aside Under Commodity Programs (1981-1987) (Carter and Coenen, 1987).

Year	Corn Acres Set Aside
1981	20
1982	128
1983	757*
1984	175
1985	203
1986	565
1987	877

* PIK Program

WATER QUALITY ANALYSIS

Objectives

This project has a consistent water quality monitoring program, and land use and land treatment activities are well documented. Therefore, the data should allow a test of whether sediment control practices can produce measurable improvement in lake water quality over the 10-year RCWP monitoring timeframe.

Specific objectives of this analysis are:

1. Examine data from water quality monitoring (pre-RCWP and RCWP) and bathymetric mapping to determine if any trends have been documented.

2. Perform covariate analysis of water quality data to determine if any statistically significant trends can be documented. Precipitation and chl *a* covariates are examined for effects on variability in water quality monitoring data.

3. Examine association of land treatment and corn acreage set aside with water quality measurements.

4. Calculate minimum detectable change (MDC) in water quality needed to document significant improvement in water clarity of Prairie Rose Lake.

5. Examine effect of discontinuing monitoring until the last two years of RCWP on the project's opportunity to show significant trends in water quality.

The project has observed persistent high turbidity levels following runoff events. The project hypothesizes that if sediment delivered to the lake is decreased by BMPs, greater light penetration triggers algal growth. Consequently, decreases in turbidity from lowered levels of suspended solids (SS) may be compensated by increases in algal turbidity.

We selected covariate analysis to determine what portion of the variability in water clarity (i.e., Secchi depth, turbidity) could be accounted for by algal growth and precipitation. This approach allows for a better understanding of the true changes in water clarity after adjustment for chl *a* and precipitation.

Minimum Detectable Change (MDC) in Secchi depth and turbidity over the monitoring period, after correcting for algal concentrations and antecedent precipitation, is of particular interest to the project. MDC is the amount of measured change in a water quality parameter required before it is considered real and not an artifact of system variability.

The project would like to discontinue monitoring until the last two years of the RCWP (1989-1990). This would leave one to three years of monitoring gap in their data set. The MDC required in Secchi depth and turbidity, corrected for known explanatory variables such as chl *a* and precipitation, is calculated for a gap in monitoring and compared to the MDC required if the project monitored continuously through 1990. Such a comparison sheds light on the opportunity for the project to document water quality trends using either monitoring strategy.

METHODS

Inspection of Pre-RCWP Water Quality Data

We examined a summary of the available pre-RCWP water quality data for evidence of water quality problems prior to 1981. The water quality data from lake sampling in the summers of 1974 and 1979 and tributary sampling following runoff events in 1979-1980 were used.

Inspection of Bathymetric Mapping Data

Bathymetric mapping surveys in 1971 and 1980 provide an indication of the lake sedimentation rate prior to the RCWP. The 1985 survey data were examined for indications of a reduced sedimentation rate under the RCWP.

Preliminary Inspection of RCWP Water Quality Data

We examined Secchi depth at the surface and turbidity, TP, OP, chl *a*, NO3-N, NH3 + NH4 at both the surface and bottom of lake sites. Most of the attention was given to Secchi depth, turbidity, TP, OP, and chl *a*. These data were retrieved from STORET and corrected for discrepancies with the project's annual reports. The lower detection limit for inorganic-N, OP, chl *a*, and NH3 + NH4 were reported when samples were below the detection limit. When the STORET code indicated that the actual concentration was less than reported, we divided the reported concentration by 2. This corresponds to one-half the detection limit.

The lake site monitoring data collected during the RCWP were examined for suitability for parametric statistical analysis, i.e., residuals normally and independently distributed with constant variance. Residuals in the analysis of site data over time were approximated by subtracting the mean value for the site-depth-year from each observation. These residuals were calculated on both original and log transformed scales for surface and bottom sampling data (pooled over sites). The Kolomogorov-D test (sample size $n > 50$) and the Shapiro-Wilk W test (sample size $n < 50$) (SAS Institute Inc., 1985) were used to test the normality of these data, and log transformations were made as necessary.

Examination of Geometric Mean, Minimum, and Maximum for Each Site-Depth Over Time

The geometric mean and range of Secchi depth, turbidity, chl *a*, TP, and OP for each site, depth, and year were plotted. The geometric mean is the antilog of the mean of the log values and closely approximates the median value of the sample distribution. Visual inspection of the plotted values are discussed in light of the information presented in the project's annual reports.

We performed analyses of variance to compare geometric means between years and/or sites for surface and bottom samples. Interactions between years and sites were examined to evaluate evidence that the differences between the sites differed over time. Orthogonal contrasts were performed to test for evidence of linear, quadratic, and cubic behavior over time. Similarities and differences between the sites are discussed. Evidence that the lake may act as a large sediment trap is discussed.

Comparison of Precipitation Data With Water Quality Measurements

Antecedent precipitation is thought to be an important variable in the lake system and may account for some of the variability in water quality monitoring data. We sought adjustment of water quality data for precipitation to minimize the effect of such variability on measurement of water quality trends.

The daily precipitation data, except for 1981 and May 1983, were obtained from the Prairie Rose Lake RCWP annual progress reports. The 1981 daily rainfall was estimated from the Iowa Department of Natural Resources gage approximately 10 km west of Prairie Rose Lake at Harlan, Iowa. Missing rainfall data for May 1983 were estimated from the gage at Audubon, Iowa, about 20 km to the northeast.

Plots of daily precipitation were compared with surface Secchi depth, turbidity and chl *a* data. The total precipitation occurring during sampling periods was compared with the general lake water clarity measured under RCWP monitoring.

Development of a Precipitation Index

An index to represent the effect of antecedent precipitation that could be matched with water quality data was developed as described in Appendix 4.A. The precipitation index is a function of the magnitude of antecedent rainfall and the number of days since rainfall. It served as a regression covariate for analysis of covariance to test for differences in the average value of a water quality parameter between levels of group variables (i.e., years and sites) after adjusting for antecedent precipitation (i.e., values of the precipitation index associated with each sample).

Multivariate covariate analysis with terms for the magnitude of the last precipitation event and the number of days this event occurred prior to sampling was performed for comparison to the derived index. This technique is also outlined in Appendix 4.A.

We found the best index related to water clarity was the product of the magnitude of the last rainfall event and $e^{(-3 * t)}$, where t is the number of days since precipitation. No improvement was found using the multivariate model.

Adjustment of Water Quality Measurements for Antecedent Precipitation: Analysis of Covariance With the Precipitation Index as a Covariate

The water quality parameters studied were Secchi depth, turbidity, chl *a*, TP, and OP. Surface and bottom samples were analyzed separately.

The first step in the analysis of covariance is to determine the statistical model which best represents the true relationships between the water quality parameters under study. The simplest model, the equal slopes model, would allow values of a specific parameter to be regressed on the precipitation index with each year and site represented by separate, parallel lines. In this simple model, the response, or slope, of each regression line is the same but the intercepts or means can be different.

The equal slopes model cannot be assumed, however, without testing the slopes for homogeneity or interactions. If the slopes are found to be different, then each line has its own slope and intercept, i.e., the response of parameters for each site and/or year can have a different relationship to the precipitation index. Interaction terms are eliminated from the model in a stepwise fashion until the simplest, appropriate model is determined.

After the appropriate model was determined, we calculated the mean values adjusted for the precipitation index (the least-squares means) to compare sites and years. Each yearly mean was adjusted to an overall common value of the precipitation index to remove some of the effect of differing precipitation patterns. Tests were also performed to determine if site means could be pooled to obtain a more powerful comparison over years. The adjusted least-squares yearly means were compared to the yearly means unadjusted for precipitation.

Evidence for trends in the adjusted yearly means for Prairie Rose Lake data were tested by using orthogonal polynomials (linear, quadratic, or cubic) given by Fisher and Yates (1943).

Adjustment of Water Clarity Measurements for Chl a and Precipitation

We assumed that water clarity is expressed by Secchi Depth and turbidity measurements. The analysis of covariance technique presented above was performed to compare Secchi depth and turbidity least squares means of sites and years after adjusting for the covariates of chl a and precipitation. Evidence for trends over time in water clarity was examined.

Association of Water Clarity With Land Treatment

Estimates of sediment delivered to Prairie Rose Lake from 1981 to 1986 were obtained from the project's annual reports (assuming a sediment delivery ratio of .32). These numbers represent the tons of soil saved as a function of RCWP BMPs, i.e., terraces, conservation tillage, and sediment retention structures. An additional term for number of corn acres set aside with cover crop under the Acres Conservation Reserve (ACR) annual federal commodity reduction program was examined for its effect on variation in water quality parameters.

Linear association of water quality with land treatment was investigated. Analyses of covariance were performed similar to the technique used with the precipitation index and chl *a* covariates. A term for either sediment delivered to the lake or a term for set-aside corn land was used instead of the YEAR term. Then, a linear relationship between the yearly means of water clarity parameters and of each land use parameter was tested using orthogonal polynomials given by Fisher and Yates (1943). In addition, multiple regression models with both land management terms were tested.

Minimum Detectable Change

Minimum Detectable Change (MDC) is the amount of change in the yearly geometric means required over time to be statistically significant (Spooner et. al., 1987). MDC represents the change required over time to be considered real and not an artifact of system variability. The procedure used to calculate MDC is given by Spooner et. al. (1987).

After correcting for algal concentrations and antecedent precipitation, the MDC in Secchi depth and turbidity over the monitoring period was calculated for two different monitoring schemes: 1) ten years of continuous monitoring; or 2) continuous monitoring from 1981 to 1986 and again from 1989 to 1990, with no monitoring in 1987 and 1988. The effect of using chl *a* concentrations and precipitation as adjustment covariates was examined. Also, the relative efficiency of using linear regression versus t-test as a statistical technique to determine water quality trends was examined.

MDC is a function of the variability in water quality parameters within sites and between years. This variability is measured by the mean square error (MSE) obtained from an appropriate regression model. A better estimate of the variability, one with more degrees of freedom and better accuracy, can be obtained using the MSEs from a model that pools residuals across sites. However, to use such a model the variance within each site must be similar for all sites. To test for similar variance among sites, we ran regression models over time to obtain MSE values (variances) for each site and depth. Bartlett's homogeneity of variance test (Snedecor and Cochran, 1967) was performed on these MSE values. The surface sites did not have statistically different MSEs and their residuals were pooled for calculation of MSEs used to determine MDCs. The same procedure was performed with the same results for bottom sites. The MSEs obtained using this procedure approximate a weighted average of the variance within each site over time while allowing the variation due to site differences to be excluded.

The next step in this technique is to determine the MSE values needed to calculate MDC values for each parameter at both surface and bottom locations. For each parameter, the regression model included a SITE term with 2 (number of sites - 1) degrees of freedom, a linear year term with 1 degree of freedom. Terms for precipitation and chl *a* were selectively included as adjustment covariates. The MSE from these models were obtained and the MDC calculated for monitoring schemes with 8 and 10 years of monitoring data.

The magnitude of observed changes in water quality parameters measured from 1981 to 1986 was calculated and compared to the calculated MDC values. The observed change for a given water quality parameter was expressed as a percent change in the predicted geometric mean values from 1981 to 1986 relative to the predicted geometric mean value in 1981. The predicted geometric mean values were calculated from the linear regression equations used to estimate the MDC values. The predicted values for 1981 and 1986 were calculated by substitution of the mean values of the precipitation covariate and chl *a* into the regression equations containing only the precipitation covariate and also from the regression equations containing both the precipitation and chl *a* covariates terms.

RESULTS AND DISCUSSION

Inspection of Pre-RCWP Water Quality Data

Pre-RCWP water quality data are available from lake monitoring studies conducted in 1974 and 1979. RCWP lake monitoring began in 1981. Monitoring sites in 1974 and 1979 were not the same as the RCWP sites. The arithmetic means of parameters sampled in 1974, 1979 and 1981 are listed in Table 4.3.

Table 4.3 Lake Surface Arithmetic Mean Values (sample number in parantheses beside mean value).

Parameter	1974[1]	1979[2]	1981[3]
Secchi depth (inches)	36.7 (3)	23.6 (5)	22.1 (10)
Chl a (ug/l)	17.3 (3)	38.6 (8)	19.6 (10)
Turbidity (JTU)	NA	14.1 (8)	10.0 (10)
TP (mg/l P)	0.06 (3)	0.32 (9)	0.08 (5)
NO_3-NO_2 (mg/l)	0.52 (3)	0.64 (2)	0.13 (5)
NH_3+NH_4 (mg/l)	0.05 (3)	0.12 (2)	0.69 (1)

[1] two sampling sites
[2] one sampling site
[3] two sampling sites – average from RCWP surface sampling at sites 2 and 3.

In 1974, Prairie Rose Lake was sampled three times at two sites as part of the National Eutrophication Survey (Monitoring Report, 1981). The water was reported to be turbid. Mean values in 1974 do not depict a water quality situation worse than in 1981 when RCWP began (Table 4.3). In the summer of 1979, a few samples were taken from the upper mixed zone of the lake for the Clean Lakes Classification Study. The mean values are very similar to those measured in 1981 at the start of the RCWP. During 1979-1980, water quality monitoring was conducted at the Elm Creek Tributary (Figure 4.2) during five rainfall-runoff events. Average storm flow turbidity was 2,031 JTUs. The average TP and OP concentrations were 1.65 and 0.72 mg/l P, respectively (Monitoring Report, 1981). Stream flows ranged from 1 to 20 cfs. Unfortunately, monitoring at this site stopped in 1981. The project estimates that the nonpoint contribution from Elm Creek represents approximately 13% of the entire watershed area. Relative loading sources from other water inputs have not been reported by the project.

Inspection of Bathymetric Mapping Data

Lake volumes calculated from the bathymetric mapping surveys are shown in Figure 4.3. The pre-project data show that sedimentation caused a loss of 18.7% (381 acre-feet) of the lake volume to occur between 1971 and 1980. The rate of lake sedimentation between 1980 and 1985 was less than the rate estimated during the period 1971 to 1980. The bathymetric mapping scheduled near the project's completion will hopefully confirm an observed reduced sedimentation rate under the RCWP.

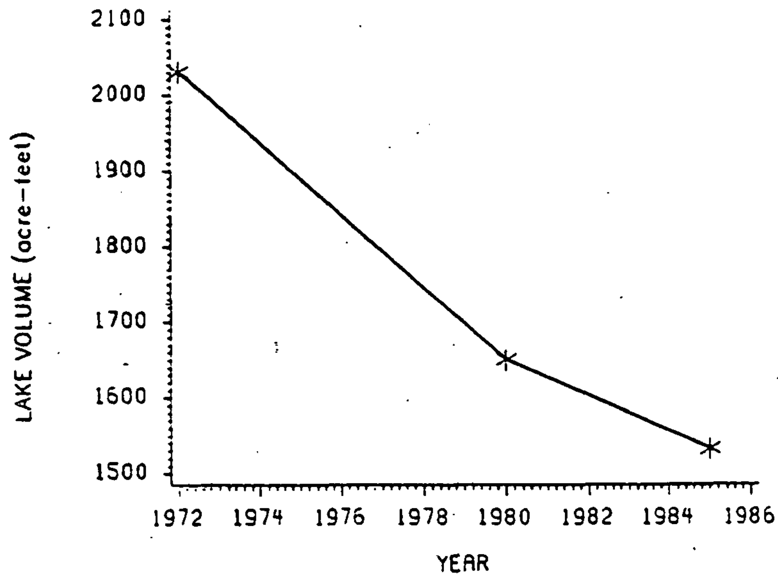


Figure 4.3 Prairie Rose Lake Volume Estimated by Bathymetric Mapping.

Preliminary Inspection of RCWP Water Quality Data

The RCWP water quality data were inspected for applicability to parametric statistics with and without the logarithmic transformation (Table 4.4). For surface sample data pooled over sites, the log transformation was required to meet normality distribution requirements for turbidity, Secchi depth, and OP. The data were normal for both original and log transformed values for TP and chl *a*. The original scale for NO_3-N was normal but the log transformed scale was not. From inspection, it appears that NO_3-N follows a uniform distribution. For bottom sample data, all the log transformed variables were normal except NH_3+NH_4 which were not normal but closer to normal than with the original scale. On the original scale, TP and NO_3-N also exhibited normal properties.

The log transformation for all variables was used in the subsequent analysis. Results were presented on the original scale as geometric means.

Table 4.4 Kolomogorov-D Tests for Normality of the Water Quality Measurements for both the Original Scale and Log Transformed Values (pooled over sites)

		Original Scale			Logarithmic Scale		
Location in Water Column	Parameter	D-Stat.	Prob>D	Visual Inspection of Cumulative Distribution	D-Stat.	Prob>D	Visual Inspection of Cumulative Distribution
Surface	Secchi Depth	.13	<.01	poor	.06	.13	good
	Turbidity	.15	<.01	poor	.05	>.15	good
	Chl-a	.07	.13	good	.09	.02	good
	TP	.14	<.01	poor	.09	.02	good
	OP	.07	.05	ok	.08	<.01	good
	NO_3	.09	.02	good	.10	<.01	poor
	$NH_3 + NH_4$	.13	<.01	ok	.12	<.01	ok
Bottom	Turbidity	.26	<.01	poor	.06	.11	good
	Chl-a	.08	.03	ok	.08	.04	good
	TP	.15	<.01	poor	.05	>.15	ok
	OP	.10	<.01	ok	.05	>.15	good
	NO_3	.08	.02	good	.08	.06	good
	$NH_3 + NH_4$	.16	<.01	poor	.10	<.01	ok

Examination of Geometric Mean, Minimum, and Maximum for Each Site-Depth Over Time

Figure 4.4 shows the yearly geometric means for Secchi depth, turbidity, chl *a*, TP, OP, NO_3-N, and $NH_3 + NH_4$ for each site-depth from 1981 to 1986. Depth refers to location in the water column, surface or bottom. Figure 4.5 shows the same geometric means with the minimum and maximum values measured per site-depth-year. From examination of Figure 4.5, it can be seen that there is considerable variability within each year. This variability makes significant trends difficult to detect over a short timeframe. However, the variance within a site-depth-year for a given water quality parameter is similar between sites. For example, the variability at site 1 is not greater relative to sites 2 and 3.

Trends over time:

Figure 4.4 displays the concentration values unadjusted for known influencing factors such as rainfall or land treatment. The data show that water quality was poor in 1981 but improved dramatically in 1982 and 1983. It then deteriorated until 1986 to near 1981 levels for chl *a*, turbidity, Secchi depth, and OP. TP had relatively high levels with a decrease in 1982 only. $NH_3 + NH_4$ levels appear to be stable after a decrease from 1981 values; but the frequency of monitoring for this parameter has increased substantially, so the direction of $NH_3 + NH_4$ trend is difficult to estimate. Nitrate-N has been high throughout the monitoring period.

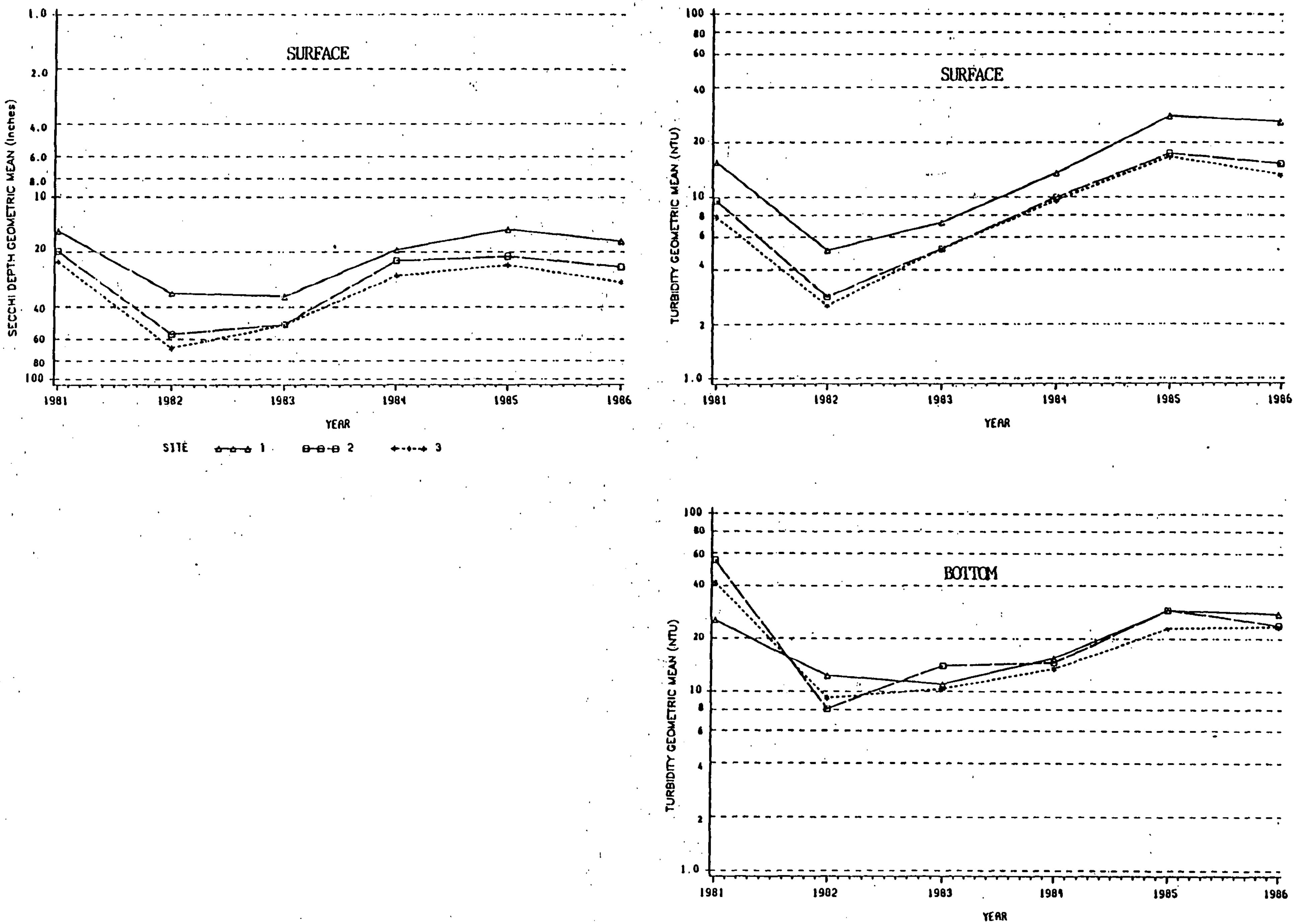


Figure 4.4 Geometric Means of Measured Water Quality Parameters for each Site-Depth-Year.

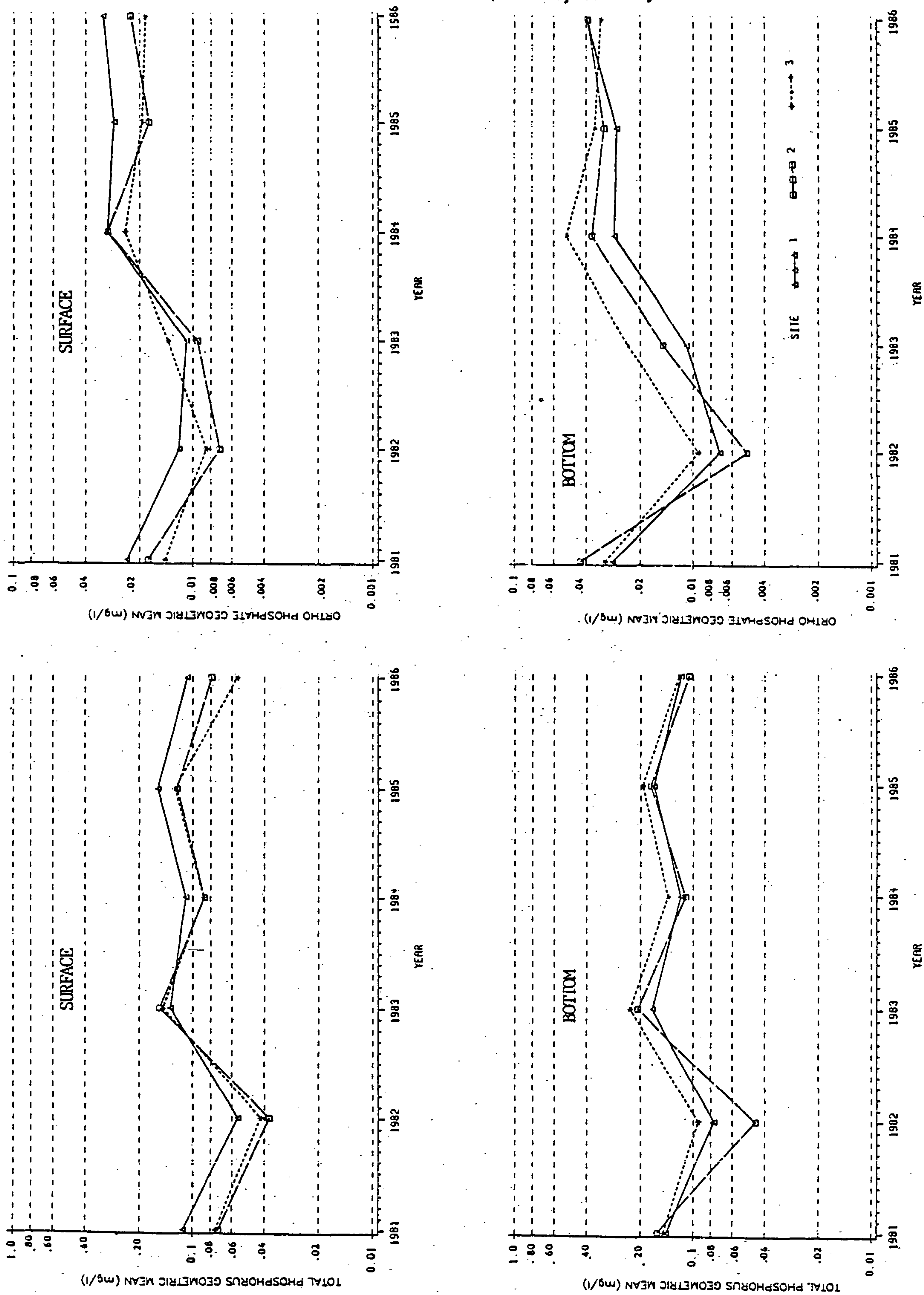


Figure 4.4 (continued)

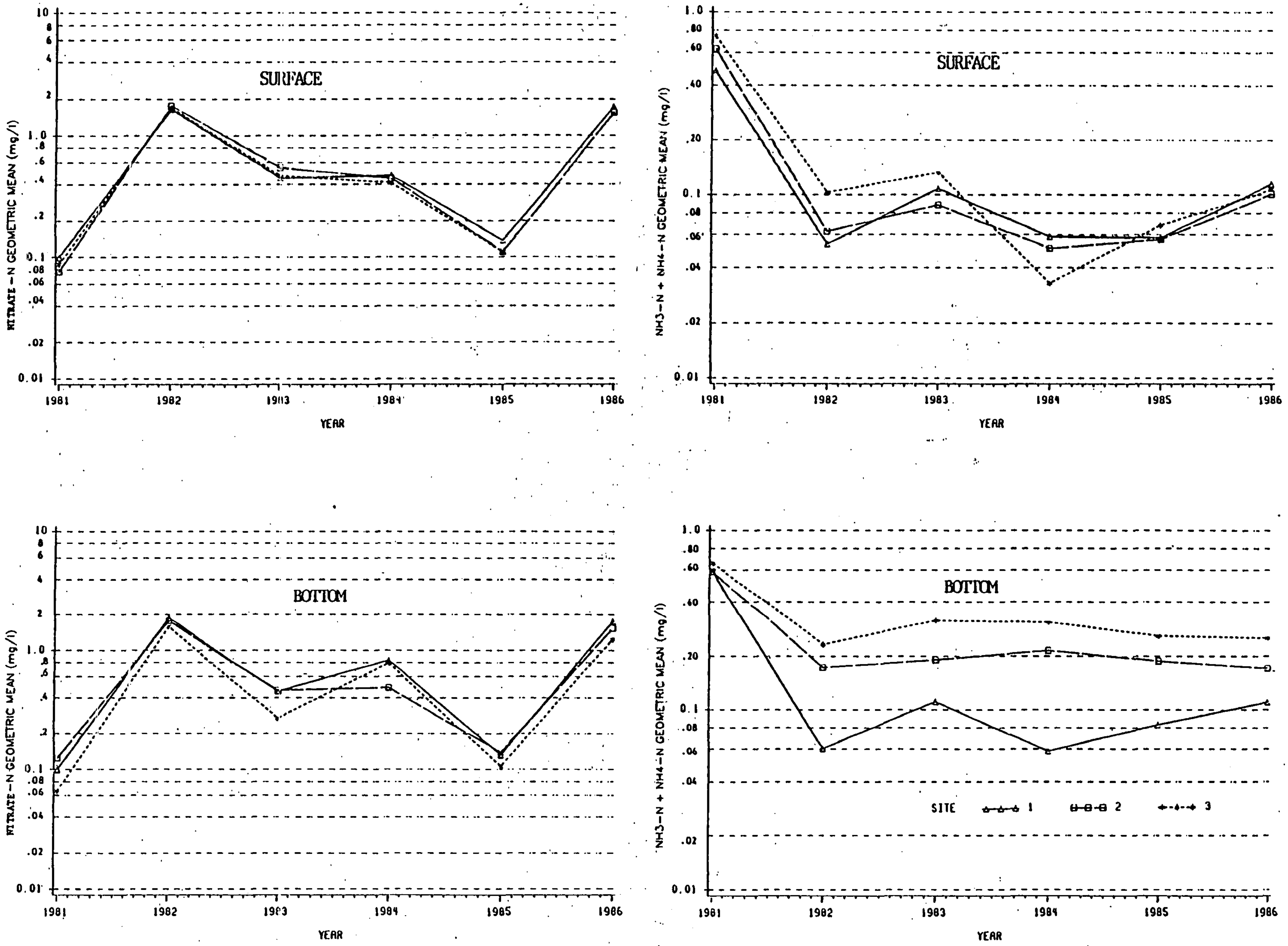


Figure 4.4 (continued)

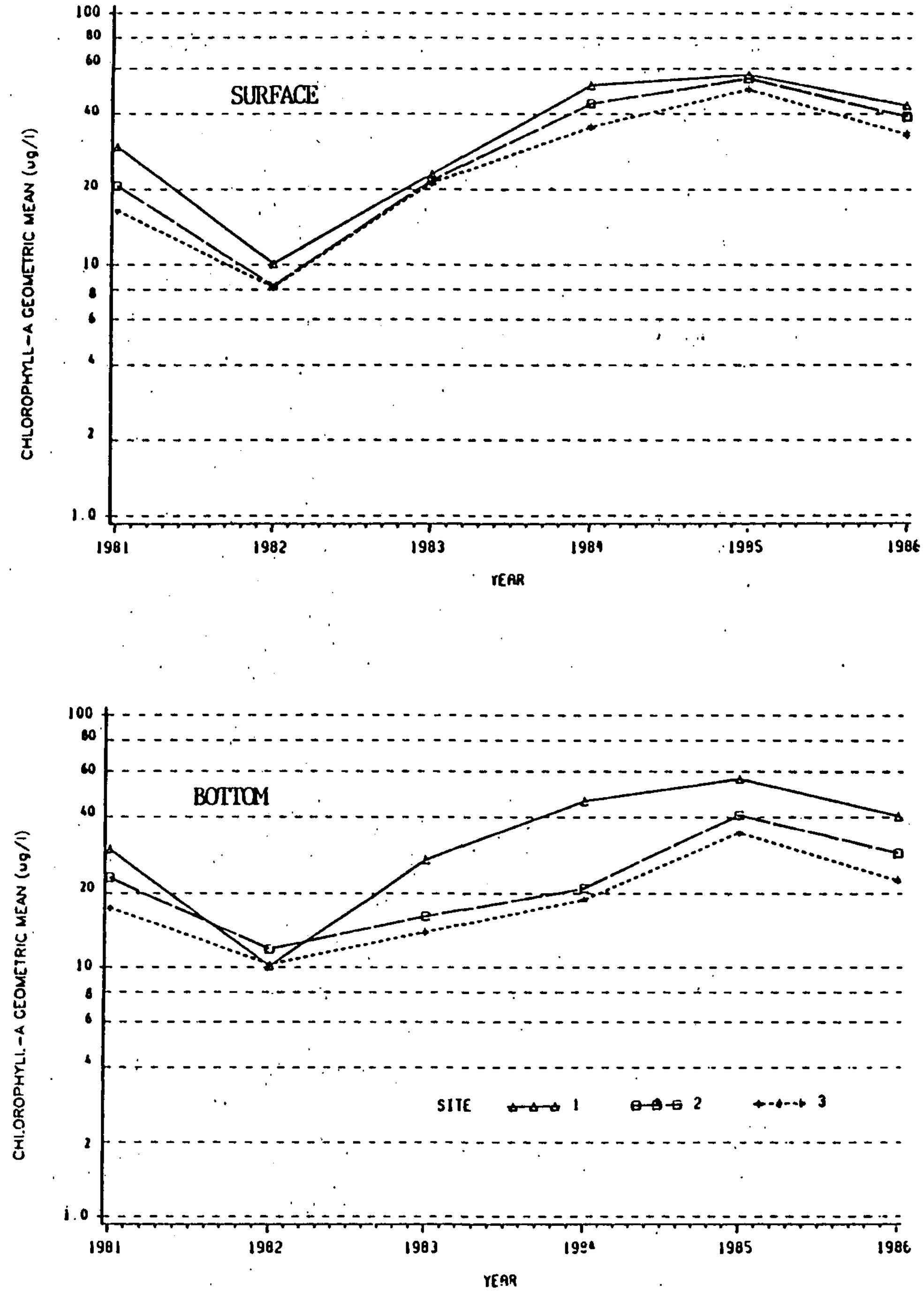
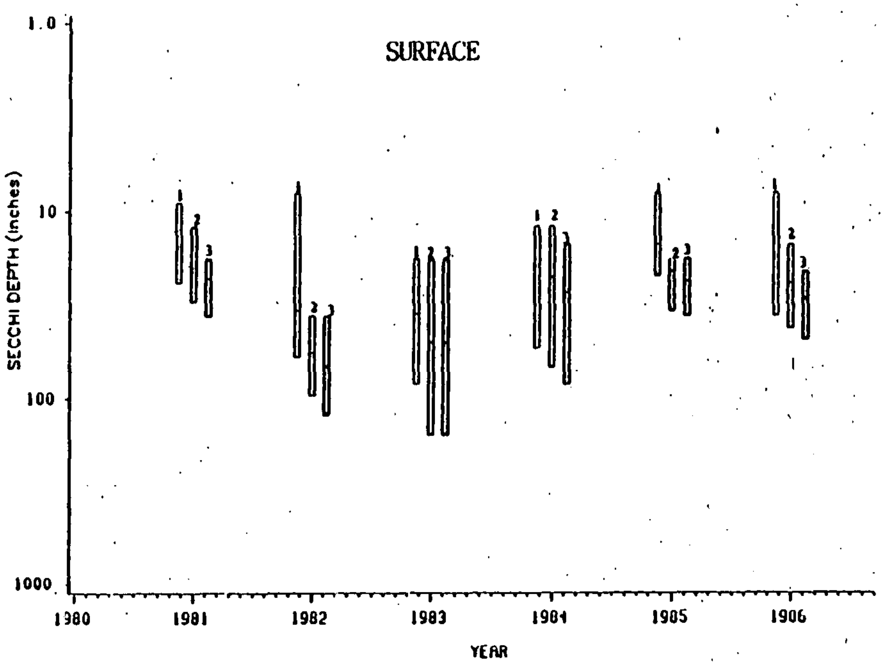
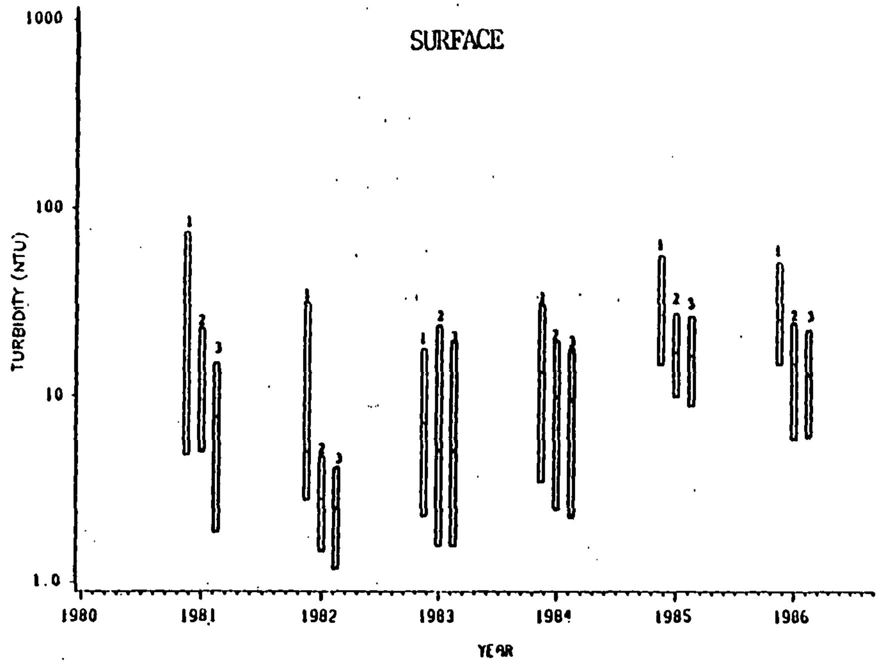


Figure 4.4 (continued)





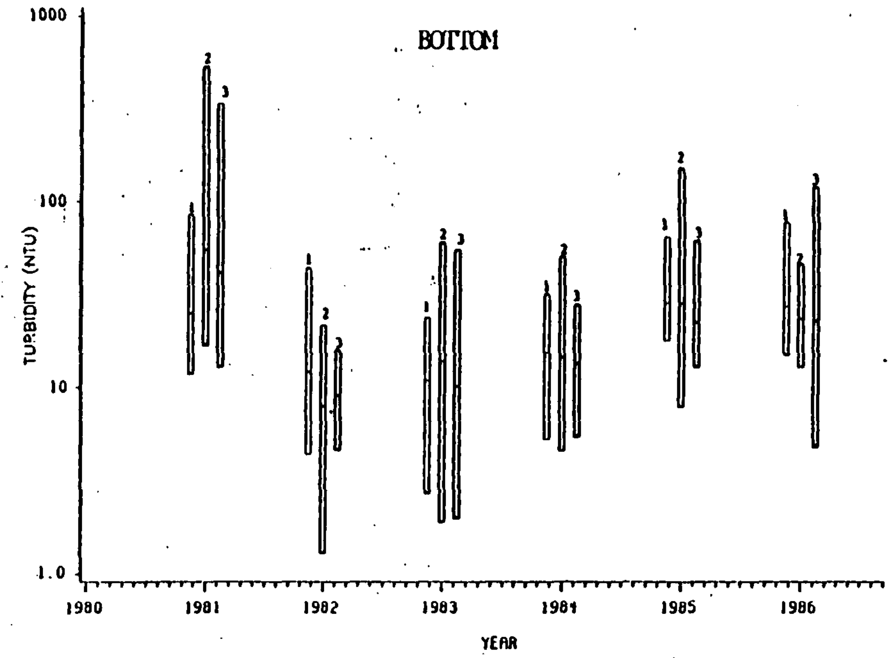


Figure 4.5 Geometric Means and Ranges of Measured Water Quality Parameters for each Site-Depth-Year.

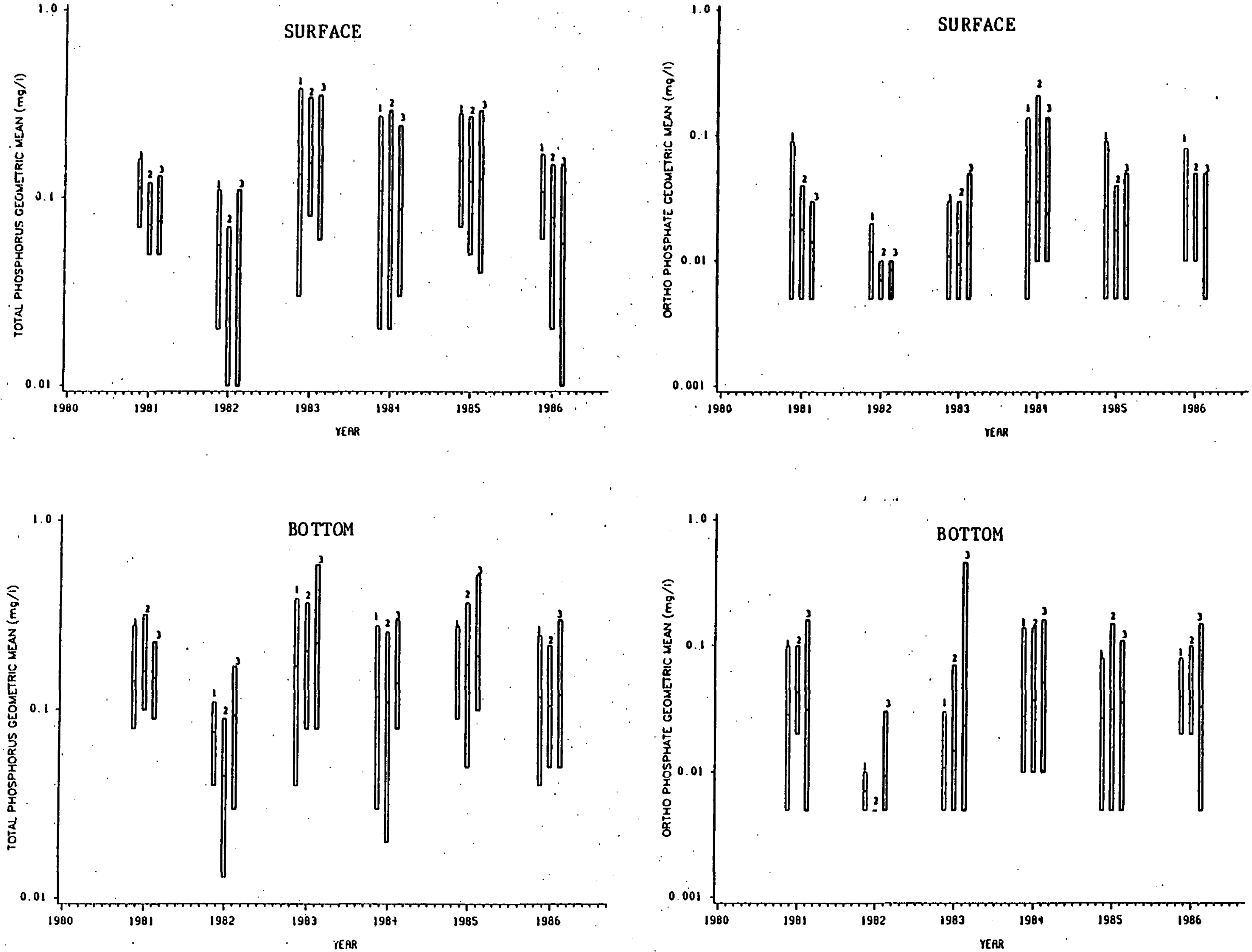


Figure 4.5 (continued)

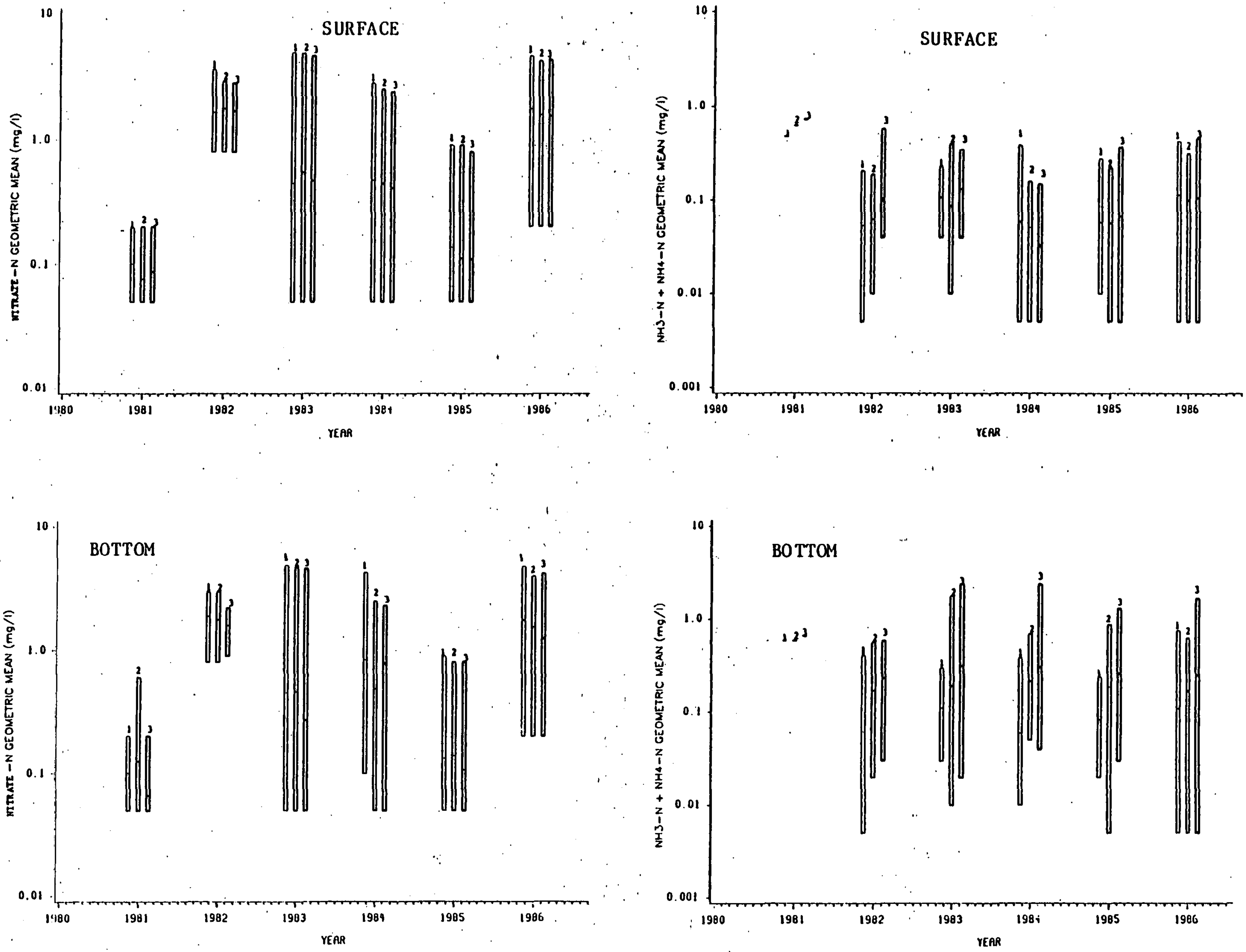


Figure 4.5 (continued)

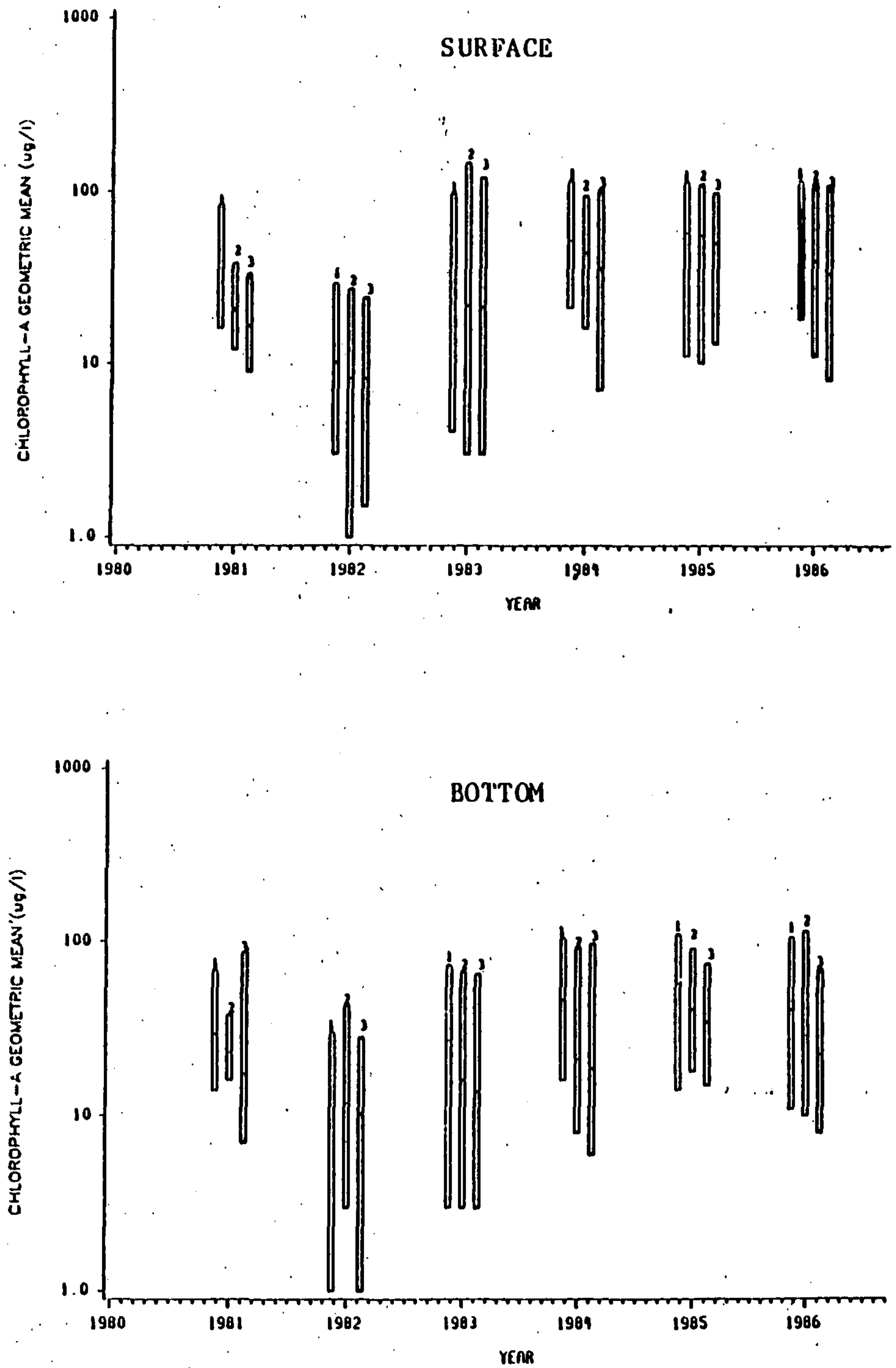


Figure 4.5 (continued)

Analysis of variance verified statistically that the data exhibit cubic behavior (i.e., fit a cubic polynomial). For all variables in surface and bottom samples at least one of the years differed from one or more of the other years ($p < 0.01$). From examination of mean values, years 1981, 1985 and 1986 are similar but statistically different from 1982 and 1983.

The project believes that the poor water quality in 1981 is due primarily to runoff events and resuspension of bottom sediment by carp. No algal blooms or submergent aquatic weed growth were observed in this year, but chl *a* was high. The project attributes water quality improvements in 1982 to sediment retention BMPs as well as proper nutrient management practices. The lower algal productivity in 1982 as compared to 1981 may be due to decreased phosphorus concentrations. The project noted growth of submerged vegetation in 1982 and attributed this to improved water clarity in that year.

In 1983, the project noted low turbidity in the first half of the sampling season and high turbidity in the second half. They attribute the increased turbidity to a greenish coloration of the water from the algal populations. The chl *a*, TP, and OP concentrations were similar to the 1981 values, but there was an algal bloom reported for 1983, the first since the RCWP began. This suggests that as light penetration improved, algal growth may have become phosphorus limiting. Algal assays confirm this scenario. If phosphorus is limiting, further BMP implementation efforts should emphasize the use of practices effective in reducing P delivery to the lake. Aquatic weed growth was noted along the entire shoreline in June and first week in July, 1983.

Compared to 1981 data, there was no substantial improvement in 1984, 1985, or 1986 values for all of the water quality parameters. In fact, surface turbidity was higher in 1985 and 1986 as compared to 1981, and mean Secchi depths were comparable to 1981. In 1984, there were no reported algal blooms. In 1985, algal blooms and aquatic weed growth were limited to shallow coves and a marsh area. High turbidity levels were recorded at the upper reach of the lake and near the dam after a rainfall-runoff event on July 18 and 19, 1985. In 1986, increases in algal populations started in July, with heavy growth in shallow coves after rainfall. Chl *a* concentrations increased in July. There was no aquatic weed growth in 1986, likely due to stocking of white amur (fish that eat aquatic weeds).

The project hypothesizes that sediment delivery to Prairie Rose Lake has decreased. They report that sharp increases in turbidity levels noted after heavy rainfall before RCWP are no longer a problem. This is a visual observation which is investigated statistically below. The project presents the scenario that improved water clarity allows increased algal growth which, in turn, causes an increase in turbidity that masks the effects of land treatment as measured at the lake. The accuracy of this scenario is investigated for statistically significant documentation below.

Comparison of lake sampling sites:

One would expect that water quality at site 1, the shallowest site (8 feet) at the upper reach of the lake (inlet), would respond more rapidly to changes in the quality of lake inflow than water quality at site 3, the deep area (24 feet) near the dam (outlet). There is no evidence for any parameter, however, that the relative behavior of site means changed for any of the years of monitoring; the magnitude of the difference between site 1 and sites 2 and 3 remains fairly constant. In fact, the low significance level for the YEAR*SITE interaction term is evidence that the relative relationships of the geometric means between sites was the same in every year.

The project reports that Prairie Rose Lake acts as a sediment trap (i.e., water clarity should be greatest at the deepest part of the lake where sediment has settled to the bottom). Our analysis of differences in parameter concentrations between sites supports this theory. The statistical tests for differences in water quality between sites were significant only for Secchi depth, turbidity at the surface, and chl *a* at the bottom.

Water clarity, as measured by Secchi depth, increased with proximity to the dam and with increasing lake depth. Mean yearly Secchi depth was lowest at site 1, in all years (Figure 4.4). Surface turbidity measured at the upper reach of the lake (site 1) is greater than near the dam (sites 2 and 3). The highest turbidity levels occurred at site 1 and were related to relatively large rainfall events prior to sampling (Monitoring Report, 1986).

Although the lake does appear to act as a sediment trap, this description is most appropriate when sediment is the primary source of lake turbidity. The project has observed little difference in Secchi depth between sites 1 and 3 after rainfall-runoff events. The project feels that water clarity is affected by algae or finer materials such as clay, which remain suspended in the water column, rather than solids, which have a tendency to settle out (Monitoring Report, 1986). It is important to note that water clarity may not be influenced solely by sediment contributed from the watershed.

Although not statistically significant, chl *a* at the surface is slightly higher for site 1 relative to sites 2 and 3; but this difference is enhanced significantly in the bottom samples, implying a relatively greater photosynthetic production level at site 1.

Differences are expected between sites due to mixing within the water column, proximity to inlets and outlets, and lake depth. Mean turbidity values at the bottom for sites 2 and 3 are much greater than at the surface for all years. This may indicate resuspension of bottom sediments. Site 1 exhibits the same pattern but to a lesser extent during 1981 to 1983. During 1984 to 1986 mean surface and bottom turbidity levels were similar at site 1, indicating a more uniform water column due to mixing. The mean Secchi depth and surface turbidity measurements indicate that sites 2 and 3 were clearer than site 1 at the surface. This may be due to greater mixing in the shallow upper reach of the lake (site 1) relative to the outlet (site 3), or a greater algal population, or sediment entering the lake, or a combination of these.

In 1981 and 1982, the mean chl *a* concentrations for surface and bottom samples were similar. This phenomenon continued in 1983 at site 1. In the remaining years, chl *a* at site 1 was slightly higher at the surface than the bottom. This is surprising since much higher concentrations would be expected in the surface zone where light penetration occurs. The smallest differences between surface and bottom chl *a* concentrations occurred at the relatively shallow site 1. From 1983 to the present, chl *a* was much lower at the bottom than the surface for sites 2 and 3. In contrast, turbidity at sites 2 and 3 was higher at the bottom than the surface. This implies that high turbidity at the bottom may be due to resuspension of lake bottom sediment, at least since 1983.

Typically, levels of TP and OP vary with inputs from the watershed, resuspension of nutrient-rich sediments on a lake bottom, and uptake and release from aquatic plants. There was no statistical evidence of differences among sites for TP and OP data for Prairie Rose Lake.

Within sites, phosphorus concentration was greater at the bottom then the surface for sites 2 and 3, but similar for both depths at site 1. The project speculates that there is greater suspension of phosphorus laden sediment and/or algae at site 1, as indicated by the nearly equal concentrations throughout the water column. They suggest that this results from wave action or fish stirring up bottom sediments at sampling site 1 near the shallow upper reach of the lake (Monitoring Report, 1981).

Comparison of Precipitation With Water Quality Measurements

Figure 4.6 shows annual precipitation recorded during the RCWP sampling periods (May - September) from 1981 to 1986. Values for surface Secchi depth, turbidity, and chl *a* are plotted for comparison. From visual inspection, there is a relationship between high rainfall events and low water clarity. Furthermore, there is strong similarity between sites 1, 2, and 3 in their magnitude and direction of change for any given parameter, high variability within a year, and no apparent trend over time.

The total precipitation during the monitoring period for each year is given in Table 4.5. Precipitation in 1983 was lower than in the other years. Note that 1983 had the highest water clarity (as measured by Secchi depth). Water clarity in 1982 was relatively high despite relatively high total rainfall during the monitoring period. The response time of Prairie Rose Lake water quality to precipitation is thought to be rapid, and the precipitation occurring within a few days of monitoring may have a large effect on the value of measured parameters. Thus, use of a precipitation index paired with each water quality sample in the analysis of covariance may be informative.

The yearly mean value of the precipitation index was calculated (Table 4.5). The mean value was at a minimum in 1983 but also low in 1982 and 1984. Conversely, it was high in 1981.

Table 4.5 Total Precipitation During RCWP Sampling Period (May - September) and Yearly Mean Value of Precipitation Index from 1981 to 1986.

Year	Total Precipitation (inches)	Precipitation Index Mean
1981	15.95	.65
1982	18.96	.25
1983	7.34	.20
1984	17.25	.28
1985	10.7	.36
1986	21.75	.45

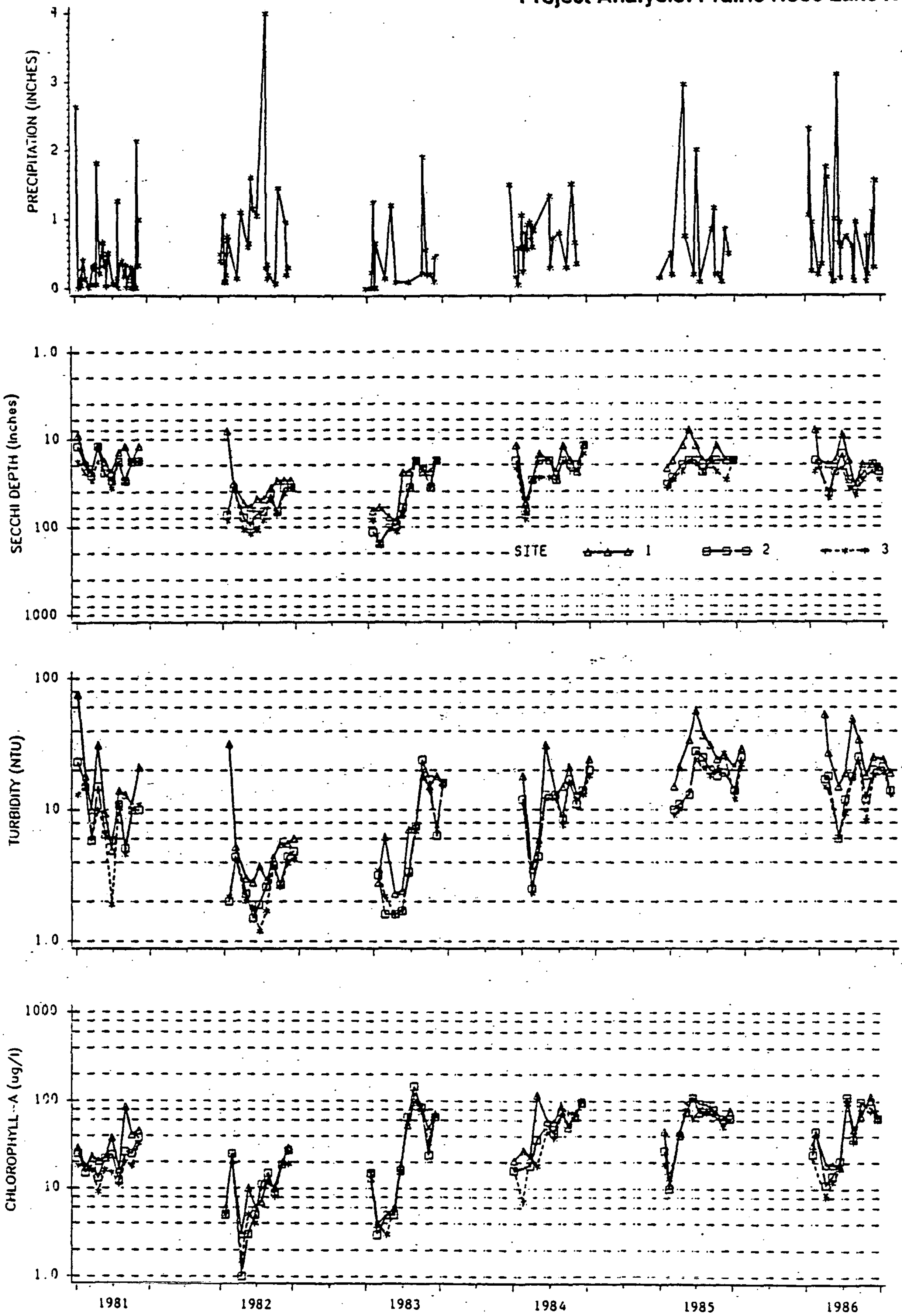


Figure 4.6 Measured Precipitation, Secchi Depth, Surface Turbidity, Surface Chl *a* for Sites 1, 2, and 3. Each sampling year is May 1 - September 30.

Adjustment of Water Quality Measurements for Antecedent Precipitation

Measurements of water quality in Prairie Rose Lake are highly variable. Some of this variation has been shown above to be due to rainfall events prior to sampling. Ideally, we would like to test if sediment contribution to Prairie Rose Lake is greater in years of events of higher rainfall before sampling; and if the data are adjusted for antecedent precipitation, did the sediment contribution to the lake decrease over time? The latter is difficult to answer because the sediment content of the water column was not measured directly. Instead, Secchi depth and turbidity were measured and are assumed as surrogates for water clarity.

Analyses of covariance were performed using the independent variables of the water quality parameters and the precipitation index as the covariate. The question asked in this analysis is: *Are the yearly mean concentrations different between years and sites after adjustment for an index of prior rainfall?*

Selection of the appropriate statistical model:

The appropriate statistical model was selected by testing the interactions between years and sites, years and the precipitation index, and sites and the index for statistical significance. For all the water quality parameters at both surface and bottom, there was no significant interaction between the years and sites. This implies there was no evidence that the sites differed in their relative behavior from year to year. The SITE and YEAR terms were kept in the model, allowing each to have its own intercept or mean in the regression of the water quality parameters on the precipitation index.

For Secchi depth, turbidity, TP, and OP, there was no evidence that the response to antecedent precipitation was different between years. However, there was significant evidence that the response of surface chl *a* concentration to rainfall was not consistent from year to year. Therefore, the slope for chl *a* plotted against the precipitation index was allowed to be different between years for surface samples. A common slope response to rainfall for each year was used for the other parameters and depths.

The relationship of surface chl *a* was examined for each year. The slope was significant and positive for 1983 and 1985, but not significant and negative in the other years. This implies that chl *a* concentration at the surface increased after rainfall events in 1983 and 1985, but was not affected by rainfall events in the other monitoring years.

For all the parameters except surface turbidity, there was no indication that the sites responded differently to precipitation levels. This was tested by the SITE*INDEX interaction. In surface turbidity, the significance level was low ($p < .06$). The slope of log surface turbidity vs. the precipitation index was 0.28, 0.14, and 0.11 for sites 1, 2, and 3, respectively. This supports the theory that prior rainfall has a greater influence on surface turbidity at the inlet to the lake. For simplicity and due to the low significance level, a common slope response for each site was assumed for all parameters.

In summary, the appropriate statistical model for surface chl *a* was a regression of chl *a* against the precipitation index -- allowing a different slope and mean for each year (YEAR*INDEX interaction term), allowing each site to have a unique mean (SITE term), but keeping the slope relationship of chl *a* vs. precipitation index constant over the sites (no SITE*INDEX interaction term). For all the other water quality parameters, the same model was used, except the slope relationship of the parameter vs. precipitation index is kept constant over years (no interaction terms).

Interpretation of the statistical models:

Table 4.6 lists the appropriate terms used in the analysis of covariance models and the significance level of each of these terms. The R^2 values are also given as an indication of the percentage of the total variation in each of the water quality parameters that was explained by the year-to-year, site-to-site, and precipitation variations. The last column is the R^2 values obtained from similar models which did not include the precipitation index term. This allows a comparison to determine the amount of variation in the water quality measurements explained by the addition of precipitation information.

Table 4.6 Analyses of Covariance Models That Examine the Adjustment of Water Quality Measurements for Antecedent Precipitation. The Significance levels of Each of the Model Terms and the R^2 Values are Given.

Location in Water Column	Parameter	Significance of appropriate terms [a]: Year	Site	PPT-Index	Year* Index	R^2	R^2 (without PPT [b])
Surface	Secchi Depth	**	**	**	na	.54	.49
	Turbidity	**	**	**	na	.62	.56
	Chl-a	**	ns	ns	**	.44	.37
	TP	**	+	ns	na	.24	.24
	OP	**	ns	**	na	.26	.20
Bottom	Turbidity	**	ns	**	na	.41	.29
	Chl-a	**	**	ns	na	.28	.28
	TP	**	ns	**	na	.28	.22
	OP	**	ns	**	na	.32	.25

[a] The analysis of covariance model:

$\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT-INDEX}) + B_4(\text{YEAR*INDEX}) + \text{Error}$

Where: log(y) = log (water quality parameter)

B_0 = Intercept

B_1 = Coefficient on YEAR term with 5 (# of years-1) df

B_2 = Coefficient on SITE term with 2 (# of sites-1) df

B_3 = Coefficient on INDEX term with 1 df

B_4 = Coefficient on YEAR*INDEX interaction term with 5 df

** There is significance evidence ($p < .01$) that at least one geometric mean was diferent from the other. In the case of the YEAR*INDEX term, this indicates a significant interaction.

* There is significance evidence ($p < .05$) that at least one geometric mean was diferent from the other.

\+ There is significance evidence ($P < .10$) that at least one geometric mean was diferent from the other.

ns There was no evidence that the means were different.

na Not applicable for this parameter.

[b] This R^2 is for a model without the precipitation index term and is given for comparison to the R^2 from the model with precipitation to show the percent of variation in the water quality parameters that can be explained by the additional information supplied by prior precipitation events.

As can be seen in Table 4.6, the sites were found to be different for Secchi depth, surface turbidity, surface TP, and bottom chl *a*. There was a significant difference between years for all parameters. Secchi depth, and surface and bottom turbidity and OP all had a significant relationship to precipitation. TP in the bottom samples appeared to be correlated with rainfall. Chl *a* at the bottom and TP at the surface were not correlated with rainfall. Chl *a* in surface samples had a positive correlation with rainfall for 1983 and 1985 only, however, no correlation was evident in the other years.

The addition of the precipitation index term explained an additional 5 to 12 percent of the measured variation for the parameters that showed a correlation to this index term (Table 4.6).

Adjusted yearly means for a common precipitation index value:
Each yearly mean was adjusted to an overall common value of the precipitation index. The mean values for site 1 differ from sites 2 and 3, however, the relative differences remain constant over the monitoring period. Therefore, the least squares means were calculated for a given year pooled over sites. Comparing means pooled over the 3 sites between years gives a stronger and simpler representation of the changes from year to year. Figure 4.7 shows the adjusted least squares means compared to the yearly means unadjusted for precipitation.

Adjusted means were found to be more appropriate (relative to unadjusted means) for comparison over time because some of the differences in water quality that may be due to differences in precipitation patterns, but not related to land treatment and other influences, are included in the model.

This procedure showed that the addition of precipitation does not strongly influence the relative behavior of the parameters over time. There is an apparent conflict in that the addition of precipitation explained a significant amount of the variation in water quality data within each site and year, but the adjusted yearly means with and without this covariate were not very different (Figure 4.7).

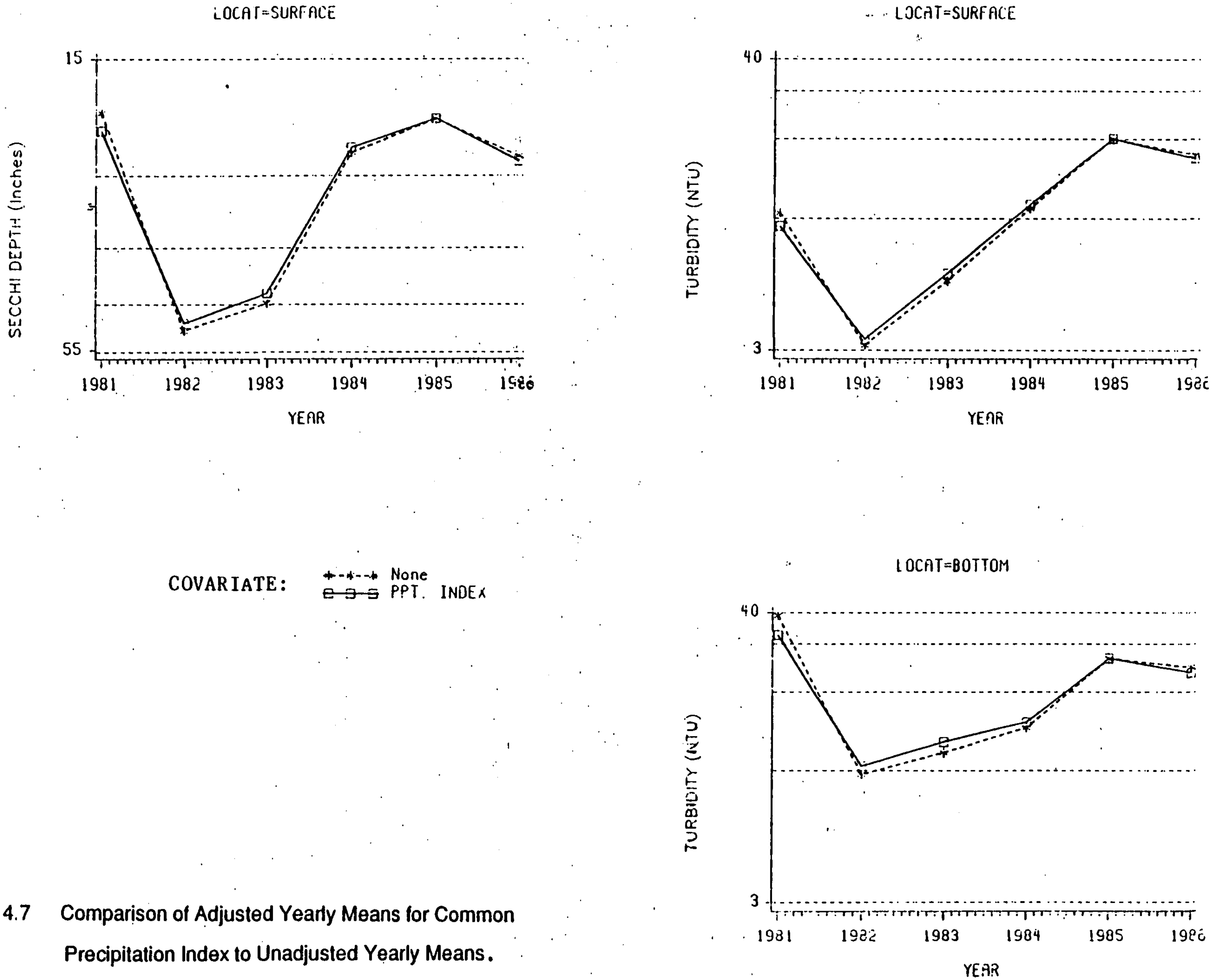


Figure 4.7 Comparison of Adjusted Yearly Means for Common Precipitation Index to Unadjusted Yearly Means.

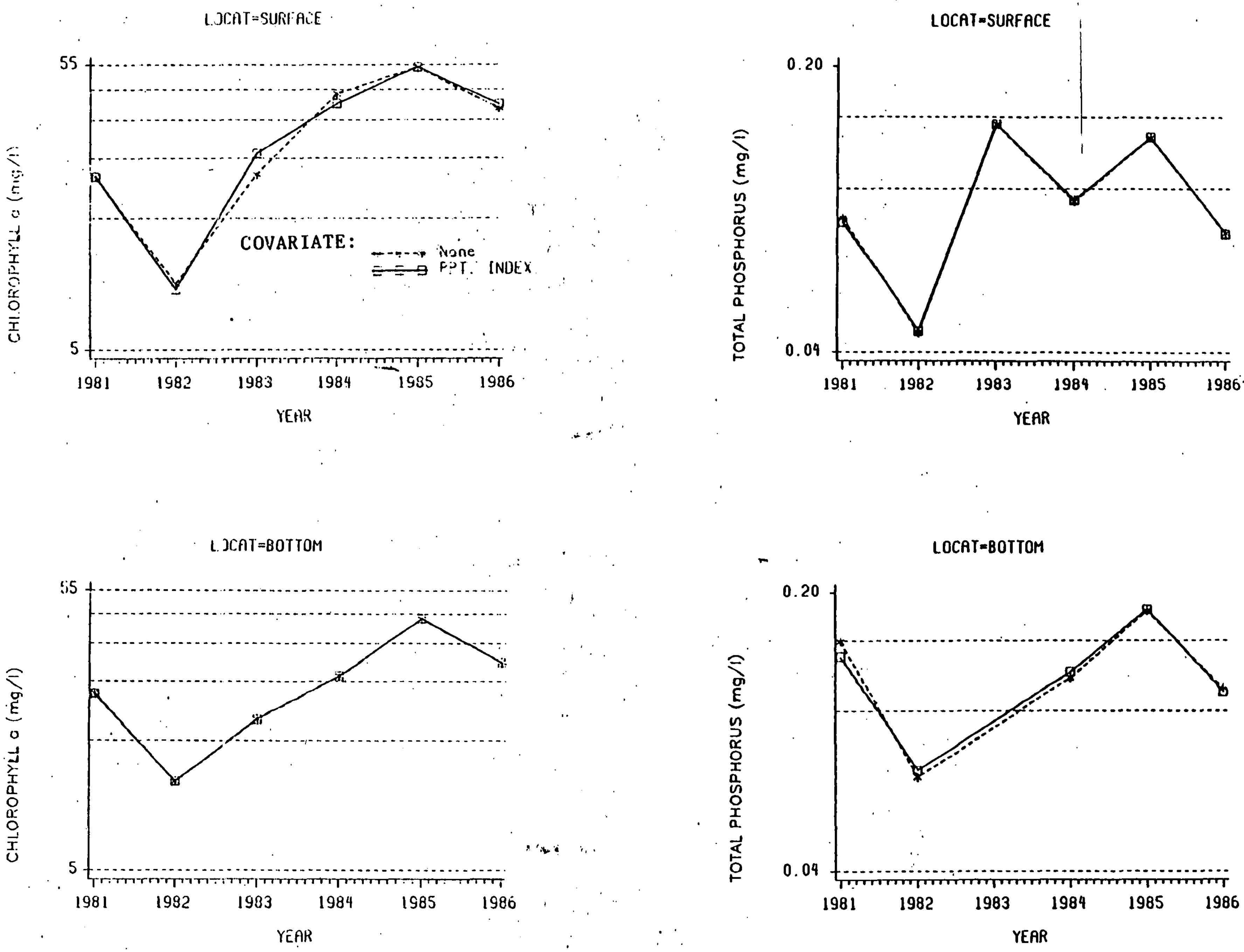


Figure 4.7 (continued)

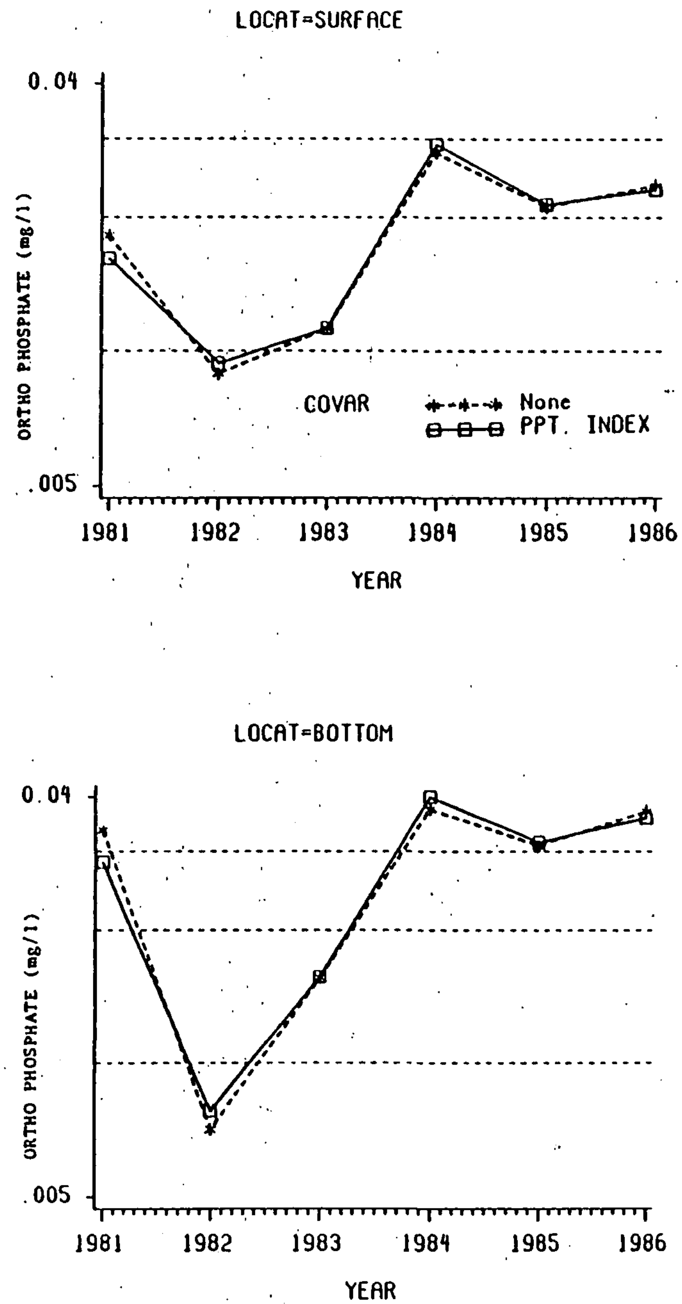


Figure 4.7 (continued)

Precipitation probably was an important factor in water quality values, but there were other sources of unexplained variability (i.e., terms not in the statistical model) that were influencing the system, also. For illustration of this point, we looked at the mean values for Secchi Depth (log transformed) and the precipitation index for each year (pooled over sites). For each year, a relative Secchi depth was calculated by subtracting the mean Secchi value over all the years from each year's value. ~~In a year~~ with relatively good water clarity, this relative Secchi Depth was positive. The same procedure was used to calculate a relative precipitation value for each year. The relative Secchi depths and precipitation values for each year are plotted in Figure 4.8.

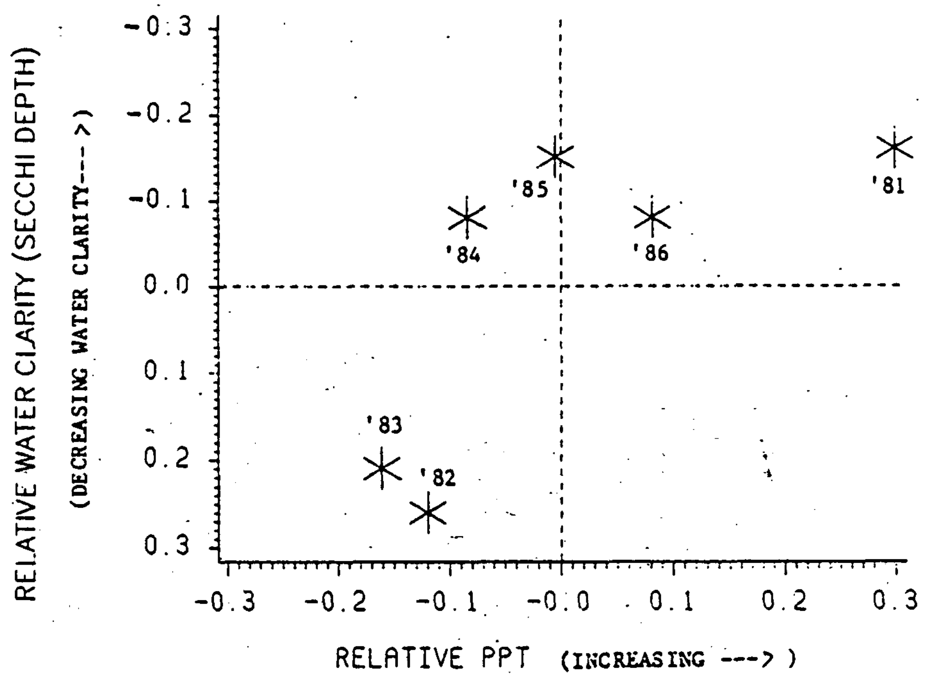


Figure 4.8 Relative Yearly Mean Values of Water Clarity and Precipitation Index.

Note that water clarity was relatively poor in 1981, 1984, 1985, and 1986, but the range in relative precipitation was very large between these years. The relative water clarity for 1982 and 1983 was good, but the relative precipitation value was not much different than 1984. The large range in precipitation values over years of similar water clarity values does not allow for large adjustments in the yearly mean values for precipitation. Therefore, the adjusted mean values were not much different from the mean values unadjusted for varying precipitation.

Trend Inspection:

Visual inspection (Figure 4.7) suggested a nonlinear, or cyclic, relationship. The least squares means were tested for polynomial linear, quadratic, and cubic behavior. The significance levels of these polynomial terms are given in Table 4.7. The direction of the linear trend (if significant) is also given. There was evidence of a linear trend in all the parameters except bottom turbidity and TP. This trend indicates a degradation of water quality over time. These same trends were observed when the precipitation index was not in the regression model, but the magnitude of the water quality degradation is less after correction for precipitation.

Table 4.7 Evidence of Linear, Quadratic, and Cubic Trends Over Time in the Water Quality Measurements. Trends are from models with (a) no covariate, (b) precipitation index covariate, (c) with both precipitation and chl *a* covariates. The direction of significant linear trends are given.

Location in Water Column	Parameter	Orthogonal Contrasts[1] — Significance of Terms: Linear	Quadratic	Cubic	Covariates[2] — Direction of Linear Trend: None	PPT	PPT & CHL *a*
Surface	Secchi Depth	**(ns)	**	**	-	-	ns
	Turbidity	**(ns)	**	**	+	+	ns
	Chl-a	**	ns	**	+	+	
	TP	*	*	**	+	+	
	OP	**	ns	**	+	+	
Bottom	Turbidity	ns	**(ns)	**(ns)	ns	ns	ns
	Chl-a	**	ns	**	+	+	
	TP	ns	ns	**	ns	ns	
	OP	**	ns	**	+	+	

[1]. Significance of terms in models with (a) no covariate, (b) precipitation index covariate, (c) with both precipitation and chl a covariates. Significance for model (c) is expressed in parentheses if different from model (b).
- ** There is significance evidence ($p < .01$) for a linear trend over time.
- * There is significance evidence ($p < .05$) for a linear trend over time.
- ns There was no evidence of a linear trend.

[2]. Covariates used in the models.
- \+ The mean parameter values are increasing over time.
- \- The mean parameter values are decreasing over time.
- ns There was no evidence of changes over time in the mean parameter values.

Adjustment of Water Clarity Measurements for Chl a and Precipitation

The project has documented a significant relationship between chl *a* and water clarity as measured by surface turbidity and Secchi depth (Monitoring Report, 1984). This supports the theory that, although suspended sediment levels were decreased by BMPs, increased light penetration triggered algal growth and, thus, Secchi readings or surface turbidity have not improved to the extent predicted by suspended sediment removal.

To investigate this theory, analyses of covariance were performed to compare Secchi depth and turbidity least squares means of sites and years after adjustment for precipitation and chl *a*. Adding chl *a* to the model should determine: *What portion of the variation in the Secchi depth measurements and turbidity can be accounted for by the algal growth and precipitation? Is there a trend over time for water clarity after making these adjustments?*

Selection of the appropriate statistical model:

The interaction terms between the sites, years, precipitation index, and chl *a* were examined for significance and, if not significant, eliminated in a stepwise fashion until valid statistical models were obtained. There was no evidence that the three-way interaction between YEAR, SITE and CHL *a* or the interaction between SITE and YEAR was significant for any of the parameters studied. There was slight evidence that the relationship between surface turbidity and chl *a*, and between Secchi depth and chl *a* differed between sites ($p < 0.10$). However, this difference appeared to be small, and the interaction between sites and chl *a* was not included in the statistical model. There is also no statistical evidence of the influence of precipitation on turbidity decreasing over time.

The appropriate covariance model for Secchi depth and surface turbidity included YEAR and SITE terms adjusted for chl *a*, the precipitation index, and the interaction between YEAR and CHL *a*. This interaction term was left in the model because there was evidence that the relationship between surface clarity and chl *a* was not the same between years. Specifically, there was a significant relationship between Secchi depth and chl *a* only in 1982, 1983, and 1984. There was a significant relationship between surface turbidity and chl *a* only in 1981, 1983, 1984, and 1986. This interaction was not present for the bottom turbidity.

Interpretation of the statistical models:

Table 4.8 lists the appropriate terms in the analysis of covariance models and the significance levels of each of these terms. The R^2 values are also given as an indication of the percentage of the total variation in each of the water quality parameters that was explained by the year-to-year, site-to-site, chl *a* and precipitation variations.

Surface and bottom turbidity and Secchi depth were related to chl *a* measurements. An additional 21 and 26 percent of the variation in surface turbidity and Secchi depth, respectively, was accounted for by adding chl *a* (Table 4.8 compared to Table 4.6). An increase of 11 percent was noticed for the bottom turbidity. From models without the precipitation term, but with the chl *a* term, the precipitation term was determined to contribute 4 to 11 percent of the total variability in water clarity measurements after chl *a* was included. Therefore, both chl *a* and precipitation were considered to be important parameters in the water clarity measurements.

Table 4.8 Analyses of Covariance Models that Examine the Adjustment of Water Quality Measurements for Antecedent Precipitation and Chl a. (The significance levels of each of the model terms and the R^2 value is given.)

Location in Water Column	Parameter	Significance of Appropriate Terms[a] YEAR	SITE	CHL a	YEAR* CHL a	PPT-Index	R^2
Surface	Secchi Depth	**	**	**	**	**	.80
	Turbidity	**	**	**	**	**	.83
Bottom	Turbidity	**	ns	**	na	**	.52

[a] The analysis of covariance model:

$$\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{CHLA}) + B_4(\text{YEAR*CHLA}) + B_5(\text{PPT-INDEX}) + \text{Error}$$

Where: log(y) = log (water quality parameter)

B_0 = Intercept
B_1 = Coefficient on YEAR term with 5 (# of years-1) df
B_2 = Coefficient on SITE term with 2 (# of sites-1) df
B_3 = Coefficient on CHLA term with 1 df
B_4 = Coefficient on YEAR*CHLA interaction term with 5 df
B_5 = Coefficient on PPT-INDEX term with 1 df

** There is significance evidence ($p < .01$) that at least one geometric mean was diferent from the other. In the case of the YEAR*CHLA term, this indicates a significant interaction.
* There is significance evidence ($p < .05$) that at least one geometric mean was diferent from the other
ns There was no evidence that the means were different.
na Not applicable for this parameter.

Adjusted yearly means for common precipitation index and chl *a* values:

The least squares means for each year corrected for chl *a* and precipitation were calculated. That is, the least squares means adjusted the yearly means to the same mean value for chl *a* and the precipitation index. These values are plotted in relation to the models without these adjustment terms (Figure 4.9). The adjustment for chl *a* and precipitation was minimal for the bottom turbidity, but significant for the surface turbidity and Secchi depth. After adjusting the yearly means of turbidity and Secchi depth for these parameters the differences per year are decreased relative to the unadjusted means.

Trend inspection:

There was no significant linear trend over time for Secchi depth and turbidity after correction for precipitation and chl *a* (Table 4.7). This is in contrast to the model without chl *a* correction where water clarity was decreasing over time. The absence of a linear trend over time after adjustment for chl *a* and precipitation could be attributed to several causes: chl *a* is not a completely accurate surrogate of algal growth; there is sampling error in the measurements and sampling; there is significant bottom resuspension; there has been a varied amount of land treatment over the project; the sediment delivered to the lake has not been reduced to the extent estimated by the project; or the effectiveness of BMPs may have been overestimated. The water quality monitoring is limited to the lake which does not allow direct measurement of nutrient or sediment inputs to the lake from runoff.

The lack of documented trends over time does not mean that the sediment delivery to the lake is not decreasing, rather this monitoring scheme has not demonstrated significant trends.

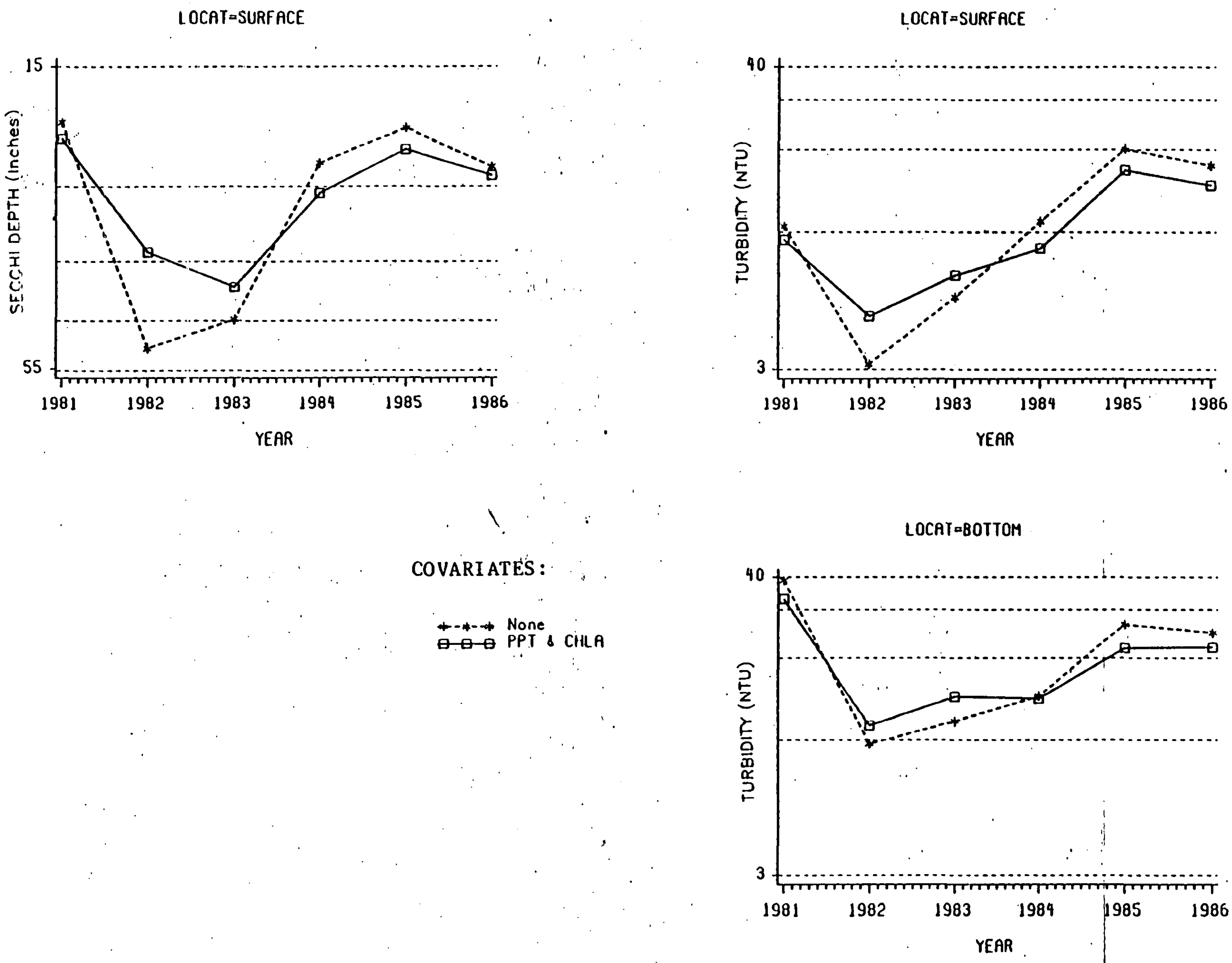


Figure 4.9 Comparison of Adjusted Yearly Means for Common Precipitation Index and Chlorophyll a Values to Unadjusted Yearly Means (pooled over sites).

Association of Water Clarity With Land Treatment

The estimated sediment delivered to Prairie Rose Lake for 1981 to 1986 is shown in Figure 4.10. The number of corn acres set aside under ACR is shown in Figure 4.11. We believe that the sediment delivery calculations include only the RCWP management effects and that the corn set aside acreage is an additional management factor in the watershed.

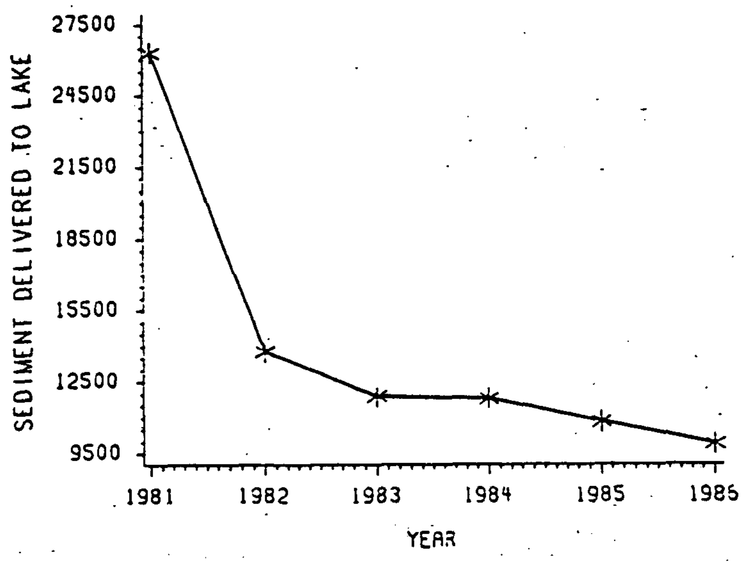


Figure 4.10 Estimated Sediment Delivery to Prairie Rose Lake from the RCWP Project Area.

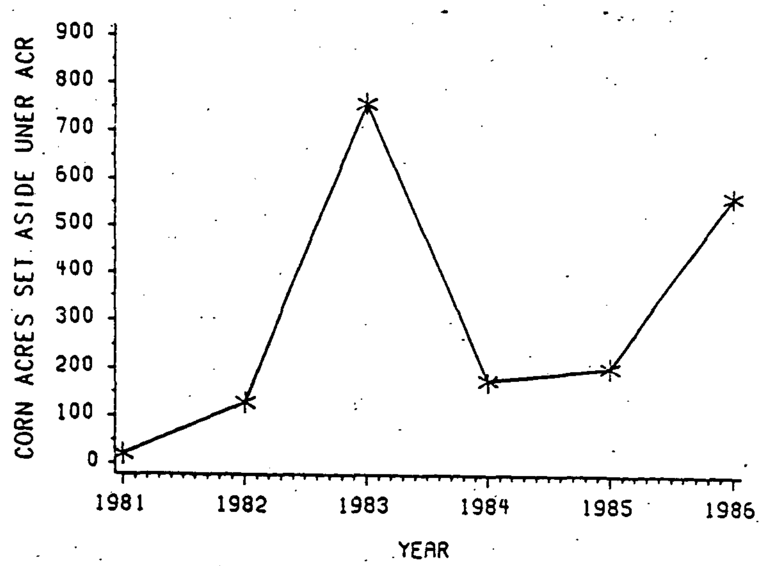


Figure 4.11 Corn Acres Set Aside Under Annual Federal Commodity Programs for 1981 to 1986.

There was no evidence of a linear association between water clarity (as measured by secchi depth or surface and bottom turbidity) and sediment delivered to the lake. A very small percentage (< 2 percent) of the year-to-year variation was explained by the magnitude of estimated sediment delivered to the lake.

Reduction of corn acreage through annual set-aside programs, however, exhibited a significant linear relationship with secchi depth and surface turbidity ($p < .01$ and $p < .05$, respectively). This relationship explained about 10 percent of the year-to-year variability in secchi depth and surface turbidity measurements. No association was found with bottom turbidity.

When terms for both land management factors are included in the model, there is some evidence ($p < .10$) that after accounting for the corn set aside acres, there is a linear relationship between the surface water clarity measurements and sediment delivered to the lake.

Minimum Detectable Change

There has been some evidence from visual observations of Prairie Rose Lake that the lake turbidity due to sediment is decreasing and the turbidity due to algal activity is increasing. As discussed above, this is not supported by statistical examination of the grab sample data. The latter suggest that although water clarity is affected by algal growth to a large extent, it is also significantly affected by precipitation. There is no statistically significant trend in water quality measurements for turbidity and Secchi depth in the 1981 to 1986 timeframe.

In the remaining years of the RCWP (1988-1990), this project has the potential to document a water quality improvement in a lake using a simple grab sample monitoring scheme because the project has a large amount of BMP implementation and a consistent water quality monitoring program. From covariate analysis of the water quality data, it is evident that variability in water quality parameters measured within monitoring sites and between years is large. Therefore, in order to document water quality improvements we must find a significant improving trend in water quality data of a great enough magnitude to be detected above system variability.

To successfully document a change, the current monitoring scheme must be continued to the project's end in order for the analysis to overcome the wide variations in parameters within and between years. If monitoring is stopped until 1989 and 1990, several interpretation problems occur. One or two years of monitoring data do not necessarily depict an accurate assessment of the conditions of the water resource. For example, 1982 and 1983 lake samples showed tremendous improvement in water quality as compared to 1981. However, these 2 years did not tell the whole picture when viewed in light of the next few years of monitoring. In addition, the statistical power of determining real trends over time increases greatly with continuous sampling records due to the ability to perform regression analyses (instead of t-tests) and gain additional degrees of freedom.

Mean square error (MSE) calculation:

The MSE and R^2 values from three models are given in Table 4.9. These models are similar to those discussed in previous sections, except the YEAR term has only one degree of freedom, i.e., a linear term only. This allows the year-to-year variation to be included in the

MSE. Several observations can be noted. The R^2 values are much lower than when the year-to-year variation was accounted for in the models shown in Tables 4.6 and 4.8. This implies that differences between the years did not exhibit a strong linear behavior. The strong influence of both precipitation and chl *a* on Secchi depth and surface and bottom turbidity was still evident.

Table 4.9 Mean Square Error and R^2 Values Obtained from Regression Models[a] With and Without Precipitation and Chl *a* Covariates.

Location in Water Column	Parameter	Model 1 MSE	Model 1 R^2	Model 2 MSE	Model 2 R^2	Model 3 MSE	Model 3 R^2
Surface	Secchi Depth	.065	.13	.054	.29	.028	.64
	Turbidity	.107	.29	.088	.42	.041	.74
	Chl *a*	.157	.20	.157	.21	–	–
	TP	.098	.04	.098	.04	–	–
	OP	.136	.08	.129	.13	–	–
Bottom	Turbidity	.160	.01	.124	.24	.094	.43
	Chl *a*	.135	.16	.135	.16	-	-
	TP	.081	.01	.078	.06	-	-
	OP	.197	.07	.179	.16	-	-

[a] The 3 regression models used to calculate MSE values were:
1. $\log(y) = B_0 + B_1(YEAR) + B_2(SITE) + Error$
2. $\log(y) = B_0 + B_1(YEAR) + B_2(SITE) + B_3(PPT) + Error$
3. $\log(y) = B_0 + B_1(YEAR) + B_2(SITE) + B_3(PPT) + B_4(CHL) + B_5(YEAR*CHL)) + Error$

Where: The year term had only 1 degree of freedom. The site term had 2 degrees of freedom.

Calculation of MDC:

The MSE values were used to calculate an MDC estimate for the following monitoring schemes. The MDC is expressed as a percent change relative to the baseline concentrations. The MDC was calculated for 3 scenarios:

1. How much change is required over the entire 10 years of RCWP to be statistically significant if a linear trend over time is tested (i.e., using a linear regression)

2. How much change is required from the pre-BMP period to the post-BMP period where the pre-BMP period is denoted by 1981-1986 (6 years) and the post-BMP period is denoted by 1987-1990 (4 years) (i.e., using a t-test to compare the pre- and post-BMP period means).

3. How much change is required from the pre-BMP period to the post-BMP period where the pre-BMP period is denoted by 1981-1986 (6 years) and the post-BMP period is denoted by 1989-1990 (2 years) (i.e., using a t-test to compare the pre- and post-BMP period means).

The first two schemes utilize monitoring data from 1981 to 1990. The only difference is in the statistical analysis employed. The BMPs were installed over several years, therefore a linear trend over time in water quality improvements is expected to be a more accurate depiction of the physical system and a linear regression should be a more powerful statistical test relative to the t-test.

If the water quality monitoring is not performed in 1987-1988 and continued in 1989-1990, then the linear regression approach is not valid and the third scheme would be appropriate.

Table 4.10 gives the MDC for each of these questions. The effect of adding the appropriate covariates to determine the system MSE can be also seen from this table. The MDCs for linear regression test were adjusted in scale for comparison with MDCs estimated using the t-test. The MDC calculated from a linear regression is the amount of change required between the two extreme years of monitoring; the MDC calculated using the t-test is the change required between the pre- and post- period means. If a linear trend is assumed then the calculated change between the two extreme years corresponds to a smaller change between the midpoint of the pre-period to the midpoint of the post-period. This adjustment in scale to compare the regression MDCs to the t-test MDCs is:

$$MDC_{adj} = MDC_{reg} * (N/2)/(N-1)$$

Where: N = number of sampling years = 10

The MDC values decrease by 3 to 5 units if monitoring is performed for 10 years instead of only 8 years. This means that the sensitivity in detecting a real change increases with longer monitoring timeframes. Assuming a linear trend over time, the linear regression technique adds an additional 3 to 5 percent sensitivity to detection of change. The addition of the precipitation index covariate and the chl *a* covariate each increases the ability to detect a real change by an additional 3 to 5 percent.

The MDCs required from 1981 to 1990, assuming a linear trend over time and the use of both the precipitation index and chl *a* covariates, were calculated to be 18 and 22 percent for secchi depth and surface turbidity, respectively (see footnote 1, Table 4.10).

Magnitude of observed changes in water quality parameters:

The percent change in predicted geometric mean values from 1981 to 1986 are given in Table 4.11. They have been predicted from linear regressions over time with adjustment for the precipitation and/or chl *a* covariates. The magnitude of these changes with correction for precipitation were large and indicate a decrease in water clarity. After correction for chl *a* the magnitude of change in Secchi depth and Turbidity was much less and not statistically different from zero. It should be noted that the change in Secchi depth from 1981 to 1986 indicated an improvement in water clarity, although not statistically significant. The surface turbidity indicated a decreased water clarity in these 6 years. However, for only 6 years of monitoring, this was not sufficient to be considered statistically real. The measurements in the water quality parameters is very large and it may require at least 10 years of monitoring to detect any real changes that are real and not artifacts of the system variability.

Table 4.10 Minimum Detectable Change (MDC) Required between the Pre- and Post- Periods to be Considered Statistically Significant. (The effect of 8 vs. 10 years of monitoring, statistical test, and use of precipitation index and chl *a* covariates are examined).

Location in Water Column	Parameter	MDC: 10 Years Monitoring Regression[1]	MDC: 10 Years Monitoring T-test[2]	MDC: 8 Years Monitoring T-test[3]
		Percent Change		
A. No Covariate Adjustments:				
Surface	Secchi	14	18	22
	Turbidity	18	23	28
	Chl *a*	21	27	32
	TP	17	22	27
	OP	20	25	31
Bottom	Turbidity	21	27	33
	Chl *a*	20	25	30
	TP	16	20	24
	OP	23	29	35
B. Adjustment for Precipitation Index Covariate:				
Surface	Secchi	13	17	20
	Turbidity	17	21	25
	Chl *a*	21	27	32
	TP	17	22	27
	OP	19	24	30
Bottom	Turbidity	19	24	29
	Chl a	20	25	30
	TP	16	20	24
	OP	22	28	34
C. Adjustment of the Precipitation Index and Chl *a* Covariates:				
Surface	Secchi	10	12	15
	Turbidity	12	15	18
Bottom	Turbidity	17	21	26

[1]. The MDC required over then entire 10 years of monitoring (1981 compared to 1990) would be these MDC values given multiplied by 9/5, a number almost twice as large. The values given here are for comparison to the t-test results and represent the equivalent percent change between pre- and post- period means. For example, the MDCs required from 1981 to 1990, assuming a linear trend over time and the use of both the precipitation index and chl a covariates, would be 18 and 22 percent for Secchi depth and surface turbidity, respectively.

[2]. The MDC required between pre- and post- period geometric means, where the pre-period was 1981 to 1986 and the post period was 1986 to 1990.

[3]. The MDC required between pre- and post- period geometric means, where the pre-period was 1981 to 1986 and the post period was 1989 to 1990.

Table 4.11 The Percent Change in Predicted Geometric Mean Values from 1981 to 1986.

Location in Water Column	Parameter	Observed Percent Change (adjusted for ppt.)	Observed Percent Change (adjusted for ppt. and chl *a*)
Surface	Secchi	-33	12
	Turbidity	256	76
	Chl *a*	225	na
	TP	26	na
	OP	97	na
Bottom	Turbidity	24	-22
	Chl *a*	117	na
	TP	9.2	na
	OP	122	na

LITERATURE CITED

Carter, J. and R. Coenen. 1987. Shelby County ASCS Office. Harlan, Iowa. Personnel communication.

Fisher, R.A. and F. Yates. 1943. Statistical Tables for Biological, Agricultural and Medical Research. Oliver and Boyd Ltd, London.

Monitoring Report. 1981. Prairie Rose Lake Monitoring RCWP Project-Year 1 (1981). March, 1982.

Monitoring Report. 1984. Prairie Rose Lake Monitoring RCWP Project. November 30, 1984.

Monitoring Report. 1986. Prairie Rose Lake Monitoring RCWP Project - Year 6.

Progess Report. 1986. Prairie Rose Lake Monitoring RCWP Project - Year 6.

SAS Institute, Inc. 1985. SAS Users' Guide: Basics, Version 5 Edition. Cary, NC: SAS Institute Inc. 1290 pp.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. 6th Edition. The Iowa State University Press, Ames, Iowa.

Spooner, J., R.P. Maas, M.D. Smolen, and C.A. Jamieson. 1987. Increasing The Sensitivity Of Nonpoint Source Control Monitoring Programs. In: Symposium On Monitoring, Modeling, and Mediating Water Quality. American Water Resources Association. p. 243-257.

ACKNOWLEDGMENTS

The author would like to acknowledge Joann Carter and Rosie Coenen, Shelby County ASCS, Iowa.

APPENDIX 4.A

DEVELOPMENT OF A PRECIPITATION INDEX.

Definition of a Precipitation Index

We developed an index variable to represent the magnitude and influence of antecedent precipitation events for each sampling date as follows:

Each precipitation event received an index value defined as the product of the precipitation amount (inches) and an exponential multiplier to adjust for the number of days before the sampling date that rainfall occurred. The equation is:

$$\text{Precipitation index} = (\text{Precipitation}) * e^{(-kt)}$$

Where: k = a constant value selected from the following list: 1, .5, .4, .3, .2, or .1
t = days since sampling date that precipitation occurred, i.e., t=0 for precipitation on the sampling date.

Smaller values of k give greater influence to antecedent precipitation events occurring farther away from the sampling date because the index has a negative exponential multiplier.

Selection Procedure

Twelve different indexes were calculated and matched with each sampling date's water quality data. Six of the indexes include only the most recent rainfall events using one of the 6 values of k (1, .5, .4, .3, .2, or .1). Another set of six indexes were computed as the cumulative index values from precipitation events since the last sampling date.

These 12 possible precipitation indexes were potential candidates for covariance variables that could help explain the observed variation in water quality parameter values. To obtain an index that would explain the most water quality variation, an analysis of covariance similar to that used in Chapter 4 was performed. Water quality parameters (log of Secchi depth, turbidity, TP, OP, and chl *a*), were regressed against values of each index assuming a separate intercept and regression line for each year with a common slope among years. This regression model had a YEAR term with (number of years - one) degrees of freedom, allowing for pooling of samples over years while correcting for different means between years. The analysis of covariance was performed for each of 3 sites and 2 depths. In addition, the 3 sites were pooled and the analysis was performed for each depth.

Results of the analyses were examined to determine the index that explains the most variation in each of the water quality parameters for each site and depth, pooled over years. To evaluate the relative effectiveness of each index, the R^2 term and the significance level for the index coefficient in the regressions were compared for each water quality variable and statistical model. The R^2 values represent the percentage of the water quality variation that can be attributed to both year-to-year variation and the precipitation index covariate.

In order to determine if the precipitation index could be valuable in the overall water quality analysis, R^2s were compared between models with and without an index. If the index covariate is not included in the model, the statistical analysis is equivalent to an analysis of variance (ANOVA) in which parameter means are compared between years. If the index covariate is determined to be important, R^2s are compared between regression models using the different indexes. If the R^2 increases as the values of 'k' decrease, the increased influence of rainfall events farther from the sampling date is indicated.

We found that Secchi depth was highly related to the precipitation index, especially if the sites were pooled. Turbidity at the surface and bottom was also highly related to rainfall; at the surface, site 1 exhibited the most significant relationship with precipitation, implying that the upper reach of the lake, site 1, is affected more by recent rainfall than sites 2 and 3. Chl *a* does not seem to be influenced by precipitation for any site or depth.

For TP, the precipitation index did not explain variations measured in the surface samples. There was, however, some indication that precipitation influenced the bottom samples ($p < .05$). The precipitation index covariate became highly significant when bottom samples were pooled over sites. Surface OP for sites 1 and 2 and bottom OP for all sites seemed to be influenced by prior rainfall events. The index covariate became highly significant when the sites were pooled for both the OP surface and bottom samples.

Given the suggested relationship between precipitation and water quality parameter values, the selection of the best index covariate was determined by comparison of R^2s (see Table 4.12). In general, when $k = 1$, the index performed poorly for all parameters and depths. When $k < 0.5$, the index was more significant relative to when $k = 1$. This implies that precipitation events removed from the sampling date were important in explaining variation in the water quality measurements and should not be ignored.

The optimal k value was slightly different for each parameter. For Secchi depth, k values of .4, .3, and .2 for the most recent rain or the cumulative index were equivalent. Using the cumulative index gave a slightly better model. For turbidity, $k = .5, .4, .3$, or .2 for the most recent or cumulative index were equivalent. For TP and OP, the index from the most recent rainfall event was better than the cumulative index and the index value with $k = .2$ was best. However, values of $k = .1$ or .3 were almost as good. Overall, k values from .2 to .5 were almost equivalent when sites were pooled. The R^2 values from the regression models with and without the index term are given in Table 4.12. Models based on each site and depth were also examined with similar results, except $k = .1$ gave an inferior fit relative to $k = .2, .3, .4$, or .5. Values of $k = .3$ were slightly better than other k values for most parameters, thus, the index chosen for use in subsequent analyses was $k = .3$ using only the most recent rainfall. This index was matched with each sampling date for the analyses in the Chapter 4.

Table 4.12 R^2 Values from Covariate Analyses to Document the Effect of the Precipitation Index Covariate (pooled over sites).

Location in water Column	Parameter	R^2 Values from Covariate Analyses[1] No Precip.Terms	With Precip. Index Terms K=.1	k=.2	k=.3	k=.4	k=.5	k=1
Surface	Secchi	.49	.54	.54	.54 (*)	.54	.54	.53
	Turbidity	.56	.62	.62	.62 (*)	.62	.62	.61
	Chl a	.37	.37	.37	.37 (ns)	.37	.37	.37
	TP	.24	.25	.25	.25 (ns)	.24	.24	.24
	OP	.20	.26	.26	.26 (*)	.25	.25	.22
Bottom	Turbidity	.29	.40	.41	.41 (*)	.41	.41	.39
	Chl a	.28	.28	.28	.28 (ns)	.28	.28	.28
	TP	.22	.28	.28	.28 (*)	.28	.27	.24
	OP	.23	.33	.33	.32 (*)	.31	.31	.27

[1] The analysis of covariance model:
$\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{INDEX}) + \text{Error}$
Where: $\log(y)$ = log (water quality parameter)
B_0 = Intercept
B_1 = Coefficient on YEAR term with 5 (# of years-1) df
B_2 = Coefficient on SITE term with 2 (# of sites-1) df
B_3 = Coefficient on INDEX term with 1 df

* The precipitation index term was significant ($p < .05$)
ns The precipitation index term was not significant ($P < .1$)

Multivariate Covariate Analysis as an Alternative to the Precipitation Index Covariate

Multivariate covariate analysis with separate terms for the magnitude of the last precipitation event (PPT) and the number of days (DAY) prior to sampling is an alternative to developing a precipitation index. This method has the advantage of simplicity, but adds more terms to the analysis of covariance model decreasing the degrees of freedom for the model error term.

Three types of multicovariate models were investigated: polynomial, logarithmic, and square root transformations on the terms in the models. For each of these, a full model was tested and stepwise elimination of non-significant terms was performed until all remaining variables were significant. This was denoted as the 'best' model.

All of the models tested contained the YEAR and SITE terms. The full model for the polynomial model included linear, quadratic, and cubic terms for PPT and DAY and all the appropriate interactions. The full model for the logarithmic model contained linear and log transformed values of the PPT and DAY terms and all the possible interaction terms (this is called the transcendental transformation). The full model for the square root model contained linear and square root transformations of the PPT and DAY terms and all their possible interactions.

The R^2 values from the 'best' model are given in Table 4.13. For chl *a* at the surface, none of the PPT or DAY terms for any model were significant. There was no evidence that the logarithmic or square root transformations were superior to the polynomial models or the precipitation index model discussed above for most of the variables. The exception was surface TP, where a very complex full model with log or square root terms was significant. This model may have very little physical meaning because of its complexity.

The precipitation index model developed was selected over the multivariate covariate analysis for the analyses in Chapter 4.

Table 4.13 R^2 Values for the 'best' Models from Multivariate Covariate Analyses to Document the Effect of the Precipitation and DAY Terms as Statistical Model Covariates.

Location in water Column	Parameter	R^2 Values from Covariate Analysis[A] Polynomial Model	Log Model	Square Root Model
Surface	Secchi	.56 (a)	.57 (3)	-
	Turbidity	.61 (c)	-	-
	Chl *a*		-	-
	TP	.25 (c)	.31 (1)	.32 (1)
	OP	.31 (b)	.35 (2)	-
Bottom	Turbidity	.43 (b)	.45 (4)	.44 (4)
	Chl *a*	.31 (b)	-	-
	TP	.27 (c)	-	-
	OP	.36 (b)	-	-

[A]. The analysis of covariance models: (Models 1-4 are for either log or square root models.)

1. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{PPT})) + B_6(\log(\text{DAY})) + B_7(\text{PPT*DAY}) + B_8(\log(\text{PPT})\text{*DAY}) + B_9(\text{PPT*}\log(\text{DAY})) + B_{10}(\log(\text{PPT})$

2. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{PPT})) + B_6(\log(\text{DAY})) + B_7(\text{PPT*DAY}) + B_8(\log(\text{PPT})\text{*DAY}) + B_9(\text{PPT*}\log(\text{DAY})) + \text{Error}$

3. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{PPT})) + B_6(\log(\text{DAY})) + B_7(\text{PPT*DAY}) + B_8(\log(\text{PPT})\text{*DAY}) + \text{Error}$

4. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{DAY})) + B_6(\text{PPT*DAY}) + \text{Error}$

a. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{DAY})) + B_6(\text{PPT*DAY}) + B_7(\text{DAY*DAY}) + \text{Error}$

b. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + B_4(\text{DAY}) + B_5(\log(\text{DAY})) + B_6(\text{PPT*DAY}) + \text{Error}$

c. $\log(y) = B_0 + B_1(\text{YEAR}) + B_2(\text{SITE}) + B_3(\text{PPT}) + \text{Error}$

- indicates that the PPT and DAY terms were not significant.

Chapter Five Project Analysis

Taylor Creek - Nubbin Slough RCWP, Florida

ABSTRACT

The Taylor Creek - Nubbin Slough RCWP Project area is located directly north of Lake Okeechobee in southern Florida. The watershed covers 110,000 acres of which 63,109 acres have been identified as critical agricultural sources of phosphorus entering Lake Okeechobee. These sources are primarily improved pastures and dairies.

The project has an extensive pre-BMP water quality data base for statistical comparison with post-BMP data. In addition, most of the BMP implementation occurred in 1985, 1986, and 1987, allowing for 4 to 5 years post-BMP water quality monitoring before the end of the project. Therefore, this project should be able to document land treatment effects on water quality.

We analyzed water quality monitoring data from in-stream sampling to determine the magnitude of measured concentration change (minimum detectable change, MDC) in TP and OP required to say with confidence that the change is real. High variability in the hydrologic system contributes to a high MDC. The impact of adjustments for precipitation, seasonality, upstream concentrations, and ground water levels on reducing the MDC were investigated. The MDC for TP ranges from 10 to 59 percent over 9 years of monitoring after adjustments for available covariates. MDC was found to be a function of subwatershed size and variability in covariates such as antecedent precipitation, ground water levels, season, and upstream concentrations.

The RCWP land treatment in the watershed emphasizes stream protection, animal waste management, vegetative cover, and grazing land protection. We found a significant decreasing trend for TP in three subwatershed and at the outflow from the project area. These trends appear to be related to RCWP land treatment under RCWP and to dairy closures.

INTRODUCTION

Background

The Taylor Creek - Nubbin Slough Basin is located directly north of Lake Okeechobee in southern Florida. The watershed covers 110,000 acres of flat land with generally coarse textured soils. The water table is high and standing water occurs in low areas during the summer months, May to October. Water flow from the basin enters Lake Okeechobee through a flow control structure, S-191 (Figure 5.1).

Lake Okeechobee is a Class I water resource covering 480,000 acres. The lake is a primary water supply for five cities along its shoreline and a secondary water supply for the eastern coastal metropolitan area from West Palm Beach south to Miami. The lake supports commercial fishing (valued at $6.3 million annually), sport fishing (valued at $22 million annually) (Bell, 1987), a significant tourist industry, and habitat for many migratory as well as endemic bird species. Water from the lake is also used to irrigate about 500,000 acres of vegetable crops, row crops, sugar cane and pasture.

High phosphorus (P) concentrations in Lake Okeechobee promote eutrophic conditions that impair all water uses. Agricultural NPS pollution has been documented as a significant water quality problem in the Taylor Creek - Nubbin Slough (TCNS) watershed (Allen et al., 1982). The TCNS Basin contributes 27% of the external phosphorus load but only 4% of inflowing water to the lake (Frederico, 1981).

The Lake Okeechobee Technical Advisory Committee (LOTAC) (1986) has recommended a 40% reduction in all phosphorus loadings to the lake to protect long term water quality using the Vollenweider Model. From a management perspective, P loadings from the TCNS basin would need to be reduced by 75% to 90% for achievement of this objective. Canfield (1988) suggests that 40% reduction of P loadings to the lake may have a minor impact on the short term quality, reflected by the P-concentration in the lake, because the lake has a substantial P reserve. Although changes in Lake Okeechobee's P impairment may be undetectable over a short timeframe, we emphasize that monitoring of external loadings provides valuable information that can be used to project long term impacts of land treatment in surrounding watersheds.

Land use in the watershed is primarily agricultural. There are 24 dairy barns with approximately 28,000 cows. There are 56 beef cattle ranches grazing about 25,000 head on improved pastures that are ditched and fertilized. Citrus groves occupy approximately 1,400 acres and require extensive drainage and irrigation. The main sources of high phosphorus loads in the watershed are thought to be stock animals (dairy cows and beef cattle) excreting while wading in streams to relieve heat stress and runoff from improved pastures (Stanley et al., 1986). Streambank erosion from animals lounging in the streams is also thought to be significant.

Project Perspectives

The primary objective of the project is to reduce phosphorus loading to Lake Okeechobee by installing BMPs. Analysis of the project's water quality data and findings can be used to address the following questions.

1. Can BMPs decrease the contribution of phosphorus to the lake from pastures located on sandy coastal plain soils that are heavily grazed by dairy cows and beef cattle?

2. Can hydrological adjustment variables such as depth to ground water and precipitation be used to correct for some of the measured variation in pollutant concentration in a biweekly grab sample monitoring program?

3. What magnitude of measured water quality pollutant changes over time are required to be considered real and not artifacts of hydrologic system variability?

4. Are we capable of detecting real changes in this highly variable hydrologic system?

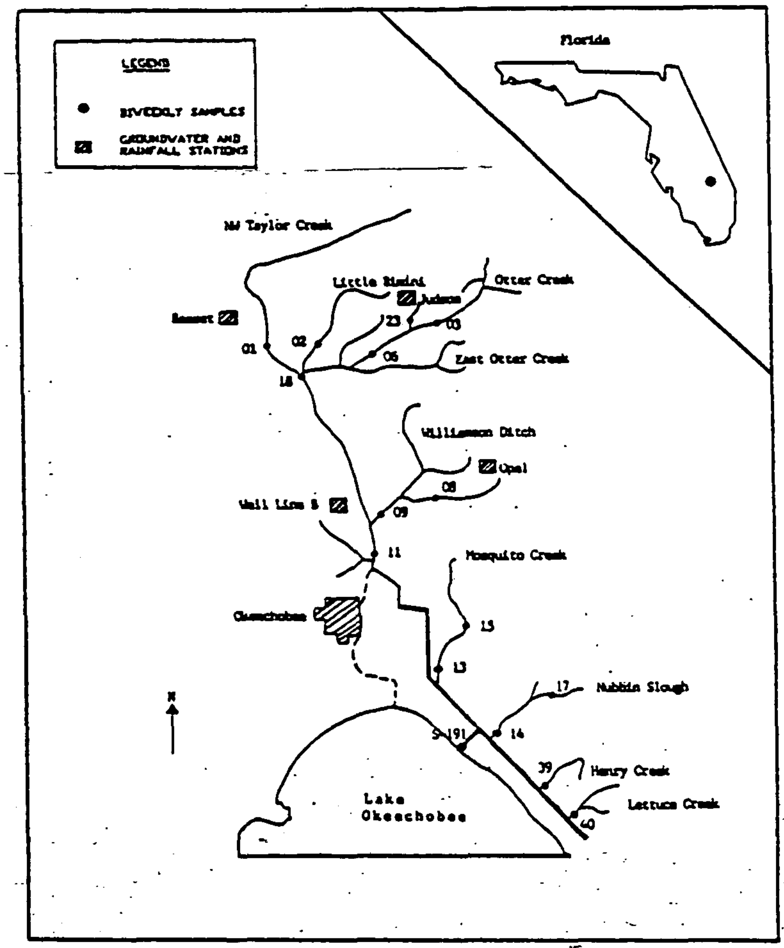


Figure 5.1 Talylor Creek - Nubbin Slough Basin. Water Quality Trend Stations and Ground Water Wells are Indicated.

Land Treatment Strategy

About 63,109 acres have been identified as critical areas needing treatment. This includes all dairy farms, all beef cattle ranches that have been extensively drained, and all areas within one quarter mile of a waterway. The project has the following three treatment goals: 1) reduce phosphorus and nitrogen loadings from the project area to Lake Okeechobee by 50%; 2) have at least 75% of the critical area under contract for BMP implementation; and 3) have all dairy farms in the project area under contract (Stanley et al., 1986).

The general treatment strategy was to install BMPs which exclude dairy cows and beef cattle from waterways and control wastewater runoff from dairy barns. Principle BMPs used are animal waste management systems, reduction of barn waste by improving water use efficiency and better effluent disposal such as spray irrigation, diversion systems, grazing land protection systems, stream protection systems, permanent vegetative cover, sediment retention, erosion or water control structures, and improving irrigation and/or water management systems. Dairy closures independent of RCWP activities may also affect water quality within the basin.

Studies by Heatwole et al. (1986, 1987a) have employed water quality models (CREAMS-WT and BASIN) to evaluate the cost effectiveness of basin-wide BMP implementation projects. Heatwole et al. (1987b) used the BASIN model to give an estimate of the expected long-term average annual response of the TCNS basin to a hypothetical 'maximum' BMP scenario. They predicted reductions of about 50% in the annual phosphorus loads from this basin.

BMP Implementation Achievements

The BMP contracting period ended in 1986 and the project clearly has achieved its contracting implementation goals. All dairies in the project area are under contract and 89% of the total critical area is under contract. BMP implementation is complete on 78% of the critical acres under contract (Stanley et al., 1986). Management BMPs are being used on 51,396 critical acres and installed BMPs are being used on 24,368 critical acres. Most of the implementation occurred in 1985, 1986, and 1987. This allows for a baseline pre-BMP period of 4-6 years. RCWP BMP implementation by subwatershed is given in Table 5.1. Dairy cow numbers, BMP emphasis, and land use changes are given in Table 5.2. Beef numbers and the acres involved for both dairy and beef are currently being compliled by the project.

Water Quality Monitoring Strategy

Grab samples are taken biweekly at 23 stream stations (Figure 5.1), some monitored since 1978. Samples are analyzed for total-P, ortho-P, nitrate-N, nitrite-N, ammonia, total kjeldahl nitrogen, pH, conductivity, turbidity (NTU), and color. Flow measurements have been taken at five stations since 1978 and at the remaining stations since 1983. Precipitation and hourly ground water levels have also been monitored at sites in close proximity to stations 01, 03, 06, 09, 11, and 23. Monitoring under the RCWP will continue until 1991. The monitoring design allows for comparison of the pre-, during-, and post- BMP implementation periods. There are many pairs of upstream- downstream monitoring stations to adjust for pollutant concentrations originating above the BMP implementation sites.

Table 5.1 BMP Implementation Under the RCWP by Subwatershed and Year for the Taylor Creek - Nubbin Slough RCWP Project Area.

Subwatershed	Year	Installed BMPs (acres)	Management BMPs (acres)	% Critical Acres Implemented	Acres Implemented
NW Taylor Creek					
	1978	0	0	0	0
Acres	1979	0	0	0	0
Critical 11,865	1980	0	0	0	0
Contracted 10,916	1981	0	0	0	0
Total 12,203 *	1982	0	0	0	0
	1983	0	8237	4.6	546
	1984	2010	6956	16	1856
	1985	3070	6956	24	2838
	1986	4488	10092	63	7532
Little Bimini					
	1978	0	0	0	0
Acres	1979	0	0	0	0
Critical 4,050	1980	0	0	0	0
Contracted 4,050	1981	0	0	0	0
Total 3,776 *	1982	539	155	13	527
	1983	671	3487	18	729
	1984	1055	3514	26	1053
	1985	1717	3789	44	1782
	1986	2113	3966	91	3686
Otter Creek	1978	0	0	0	0
(incl. E. Otter Crk.)	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 10,753	1981	0	0	0	0
Contracted 10,487	1982	830	0	6.8	734
Total 10,753 *	1983	1952	6000	15	1573
	1984	2744	7172	24	2622
	1985	4768	10372	44	4719
	1986	5530	10080	75	8075
Main Taylor Creek	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 6,464	1981	0	0	0	0
Contracted 4,809	1982	0	0	0	0
Total 11,031	1983	88	675	0	0
	1984	584	1426	8.9	577
	1985	2709	2972	39	2549
	1986	4430	4521	67	4328

* Otter Creek, NW Taylor Creek, and Little Bimini are not perfectly defined hydrologically. There is an additional 8077 acres in the Taylor Creek Headwaters defined by these 3 subwatersheds, but these are not critical.

(Table 5.1 continued on next page)

Table 5.1 (continued)

Subwatershed	Year	Installed BMPs (acres)	Management BMPs (acres)	% Critical Acres Implemented	Acres Implemented
Williamson Ditch	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 9,774	1981	0	0	0	0
Contracted 9,689	1982	0	0	0	0
Total 21,026	1983	0	2309	1.0	100
	1984	636	8431	6.9	678
	1985	2696	8431	25	2422
	1986	3296	8220	99	9689
Mosquito Creek	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 4,101	1981	0	0	0	0
Contracted 3,663	1982	0	0	0	0
Total 12,836	1983	0	0	0	0
	1984	0	0	0	0
	1985	392	3044	5.8	239
	1986	809	3124	45	1832
Nubbin Slough	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 7,091	1981	0	0	0	0
Contracted 6,978	1982	0	0	0	0
Total 11,934 **	1983	545	2791	0	0
	1984	864	3850	11	768
	1985	2264	5156	28	1954
	1986	2993	6617	80	5652
Henry Creek	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 4,255	1981	0	0	0	0
Contracted 2,445	1982	0	0	0	0
Total 10,049	1983	0	2240	0	0
	1984	367	1896	5.2	220
	1985	367	1896	5.2	220
	1986	506	1938	56	2396
Lettuce Creek	1978	0	0	0	0
	1979	0	0	0	0
Acres	1980	0	0	0	0
Critical 4,756	1981	0	0	0	0
Contracted 2,743	1982	0	0	0	0
Total 16,247	1983	0	0	0	0
	1984	0	1353	0	0
	1985	199	966	2.9	137
	1986	208	2661	5.8	274

** The total area my be larger by approximately 2800 acres with non-critical acreage east of Mosquito Creek.

Table 5.2 BMP Emphasis, Dairy Cow Numbers, and Land Use Changes by Subwatershed and Year in the Taylor Creek - Nubbin Slough RCWP Project Area from 1978 to 1987.

Subwatershed & BMP Emphasis	Year	Dairy Cow Numbers	Other Land Use Changes
N. W. Taylor Creek	1978	5500	
	1979	5500	
Fencing,	1980	5500	
Pasture Mgt.	1981	5500	'81 McArthur Farms changed from 600-800 beef cows to 400-500
	1982	6300	dairy heifers & changed to high P concentration feed.
	1983	6300	'82 1 stock watering pond installed outside a calf-
	1984	6500	heifer operation.
	1985	6500	
	1986	6500	
	1987	6500	
Little Bimini	1978	3173	
	1979	3639	
Fencing,	1980	4607	
Pasture Mgt.	1981	4476	
	1982	4472	
	1983	4702	
	1984	4784	
	1985	4966	'85 New dairy under construction.
	1986	4794	'86 Improvement will depend on handling pasture runoff
	1987	5039	from high intensity areas located in the headwaters drainage.
Otter Creek	1978	8336	
	1979	8121	
Fencing,	1980	8058	June 25,1980 start F&R dairy shutdown, Aug 25 complete
Diversion,	1982	8214	shutdown (dairy was between stations 03 and 04).
Waste water	1982	8300	
utilization,	1983	8303	July-Oct'83 maintenance operations by dragline in Otter Ck.
Pasture Mgt.	1984	8792	causing increased drainage runoff throughout Otter Ck.
	1985	8097	1984-85, Wilson dairy (500-700 cows) buy out upstream of stn.
	1986	7966	,23 – their lagoon had discharged into Stn. 23.
	1987	7759	'86 1 new dairy, 1 dairy closure due to DTP program.
Main Taylor Creek	1978	2343	Watershed has low intensity beef compared to other watersheds
	1979	2350	with high intensity dairy.
Fencing,	1980	2248	
Pasture Mgt.,	1981	2361	
Ponds.	1982	3093	
	1983	3987	
	1984	2908	
	1985	2978	
	1986	3223	
	1987	3138	
Williamson Ditch	1978	2000	
	1979	2000	
Fencing,	1980	2000	
Nutrient Mgt.,	1981	2000	
Pasture Mgt.	1982	2000	
	1983	2000	
	1984	2000	'84 Construction of a new sewer treatment plant w/ a spray field.
	1985	2000	
	1986	2000	
	1987	2000	

Table 5.2 (Continued)

Subwatershed & BMP Emphasis	Year	Dairy Cow Numbers	Other Land Use Changes
Mosquito Creek			
Fencing, Pasture Mgt.	1978	7578	
Barn waste water Mgt.	1979	7528	
Improved effluent disposal	1980	7110	'81 Shutdown of 2 dairies (from 5 previously),
at 500 calf operation	1981	8425	decrease from 5000 to 2000 a.u.
Improved existing seepage	1982	7143	
fields plugging off direct	1983	5700	
drainage to Mosquito Ck	1984	5635	'85 2 dairies back into production.
Reshaping high intensity	1985	5307	'86 Lots of BMPs on 3 dairies upstream of stn.15.
pasture; eliminated many	1986	7152	
on-farm drainage ditches	1987	5604	
to Mosquito Creek.			
Nubbin Slough	1978	4307	'78 All the dairies are between stations 14 & 17.
	1979	4331	
Fencing,	1980	4444	
Pasture Mgt.	1981	4917	Oct.02'81 Introduced dairy heifers upstream of station 17
	1982	4957	
	1983	4418	
	1984	5428	
	1985	5097	
	1986	6124	Summer'86, breach of sediment basin downstream from stn. 14
	1987	6990	directly influenced by dairy effluent 700 yards upstream.
Henry Creek	1978	1805	
	1979	1590	
Improvements in 2nd	1980	1492	
lagoon and calf	1981	1501	
operation runoff,	1982	1346	~ 82-86, problem with secondary lagoon effluent & high
Pasture Mgt.,	1983	1061	intensity runoff from calf operation.
Fencing.	1984	1138	
	1985	1390	
	1986	1800	
	1987	1687	
Lettuce Creek	1978	2000	
	1979	2048	
Spray irrigation from	1980	2014	
secondary lagoon,	1981	1977	
Pasture Mgt.,	1982	2091	
Fencing.	1983	1984	
	1984	2041	
	1985	2011	
	1986	2000	
	1987	2268	

METHODS

Total phosphorus (TP) concentrations from 15 of the Taylor Creek - Nubbin Slough water quality monitoring stations were examined using parametric statistical analysis. Initially, the standard distribution assumptions on the residuals were investigated. The residuals are the differences between the predicted and the observed values from the planned statistical analyses. Assumptions included normality, independence, and constant variance over time. Residuals were approximated by subtracting the mean value for each station- year from each observation. The project had previously noted that the concentration data were not normally distributed and that the empirical distribution is controlled by a few outlier values (Ritter and Flaig, 1987). This was supported by the Kolomogorov-D test (SAS, 1985a) on the approximated residuals. We used log transformation in all the analyses to minimize the violation of the assumptions.

The TP concentrations measured at the water quality monitoring stations were examined visually to establish the magnitude of the water quality problem. Discussion of the relationship of TP concentrations between stations is included. Project staff believe TP concentrations in the tributaries are related to the water table depth and antecedent precipitation (Ritter and Flaig, 1987). Variability in the water table depths and rainfall is also discussed.

Several hydrological and meteorological indexes were developed to correspond with the biweekly grab samples: 1) average water table depth one day, two days, three days, or seven days prior to sampling, 2) a moving average of the last seven days precipitation giving more influence to larger magnitude events closer to the sampling date, and 3) an indicator variable to separate the wet season (May 15 - October 15) from the dry season. This latter index could be used for all stations and was not limited to those that had water table depth and precipitation measurements.

We define the minimum detectable change (MDC) as the minimum change required in a pollutant concentration over a given period of time to be considered real and not an artifact of hydrologic system variability. The MDC is expressed as a percent decrease relative to the initial geometric mean concentration. To clarify, MDC is the percent change over all years, not a per year change, and depends on the number of monitoring years considered. The MDC is also a function of the statistical tests employed, the covariates used in the analyses to 'adjust or explain' the variability in the measured data, the presence of autocorrelation, the number of samples taken per year, and the variability of the measured observations.

The MDC was calculated for each station assuming a linear trend over time as described by Spooner et al. (1987). The standard deviations on the slope over time from linear regression models were utilized to calculate the MDC required. The Durbin Watson Test for autocorrelation was performed to determine if TP concentrations were related to previous measurements (SAS, 1985b). If autocorrelation is present, the following occur: (1) Standard errors on the coefficients calculated by ordinary least squares without paying attention to autocorrelation are not valid; (2) The true standard errors are not those indicated by ordinary least squares computer programs because ordinary least squares does not take into account the presence of the missing lag variable(s); (3) The standard errors calculated by generalized least squares regressions which account for autocorrelation are valid and are smaller than those for the true standard errors. Note that neither the true standard errors from a model without the autocorrelation term or from the correct autocorrelation model correspond to the standard errors calculated by ordinary least squares computer programs; (4) The standard errors on the slope calculated by the correct autocorrelation model will often be larger than those incorrectly calculated by ordinary least squares. Thus, to be truly significant, a change must be larger than is indicated by ordinary least squares. If autocorrelation is significant, it must be accounted for in the regression models for the appropriate calculation of the standard deviation of the slope over time. Autocorrelation was significant at every station. Therefore, we calculated MDC after correcting for autocorrelation by the use of an autoregressive model of order 1 (SAS, 1985b).

The MDC was also calculated after the addition of a covariate index for seasonality (wet or dry). For the water quality monitoring stations in close proximity of water table depth and precipitation data, the indexes for these variables were added to the autoregressive models and a new MDC was calculated. In addition, for the Otter Creek, Mosquito Creek, and Nubbin Slough subwatershed, upstream TP concentrations were also added as a covariate in autoregressive models on downstream TP concentrations. At station 06, covariates for water table depth, precipitation, and upstream TP concentrations were used to calculate MDC values. Although stream flow may have been a meaningful covariate, flow data was not available. Ground water table depth is thought by the project to be an surrogate covariate for the project area hydrology.

The magnitude of observed changes in TP measured from 1978 to 1986 was calculated and compared to the calculated MDC values. The observed change was expressed as a percent change in the predicted geometric mean value from 1978 to 1986 relative to the predicted geometric mean value in 1978. The predicted geometric mean values were calculated from the linear regression equations used to estimate the MDC values. Specifically, the predicted values for 1978 and 1986 were calculated by substitution of the mean values of the covariates into the regression equations.

Tests for significant changes over time (i.e. changes greater than the MDC) at each station were performed. The significance and direction of the TP concentration change is discussed in light of land treatment in each subwatershed.

RESULTS AND DISCUSSION

Total phosphorus and orthophosphate-phosphorus concentrations measured at the water quality monitoring stations were examined visually to establish the magnitude of the water quality problem. The OP and TP concentrations were of similar magnitude at all stations, indicating that most of the phosphorus is in the dissolved phase. The TP and OP concentrations at the outflow from the project area to Lake Okeechobee are plotted in Figure 5.2. Concentrations of TP are scattered around 1 mg/l with an apparent slight decreasing trend over time.

The TP concentrations measured in Taylor Creek (stations 18 and 11) range from 0.25 to 5 mg/l with a majority around 1 mg/l. Northwest Taylor Creek (station 01) has TP values ranging from 0.01 to 1.75 mg/l. This subwatershed has very little dairy activity and is used primarily to raise beef cattle. Williamson Ditch and Lettuce Creek also exhibit moderate TP concentrations ranging from 0.01 to 1.75 mg/l. The remaining watersheds exhibit much higher TP concentrations. For example TP ranges from 0.5 to 7.5 mg/l in Otter Creek at stations 03 and 06 (Figure 5.3). TP concentrations at station 23 on Otter Creek are commonly above 10 mg/l, although the total phosphorus load is relatively small due to low discharge. Outlets from the subwatersheds Nubbin Slough, Little Bimini, Mosquito Creek, and Henry Creek have high TP concentrations, varying around 4 mg/l. The concentration of TP at the project outlet (Station S191) are lower than those in the tributaries upstream in the watershed probably due to dilution and phosphorus removal mechanisms in the watershed (Figure 5.4).

The project believes that TP concentrations in the tributaries are related to water table depth and antecedent precipitation (Ritter and Flaig, 1987). By their scenario, when the water table rises to within 2 feet of the land surface, runoff occurs, increased TP concentrations in the surface water. Monthly minimum, mean, and maximum water table depths are depicted in Figure 5.5 for the Judson well monitoring station, close to monitoring stations 03, 06, and 23. The data show large variability in water table depths. In addition, a high water table occurs during the wet season from May to October. The variability in monthly precipitation can be also be seen in Figure 5.5. Low concentrations of TP occur when the water table depth is relatively deep. This is a significant relationship ($r = .35$), although the scatter is substantial, implying that water table depth does influence TP concentrations but is not the only factor.

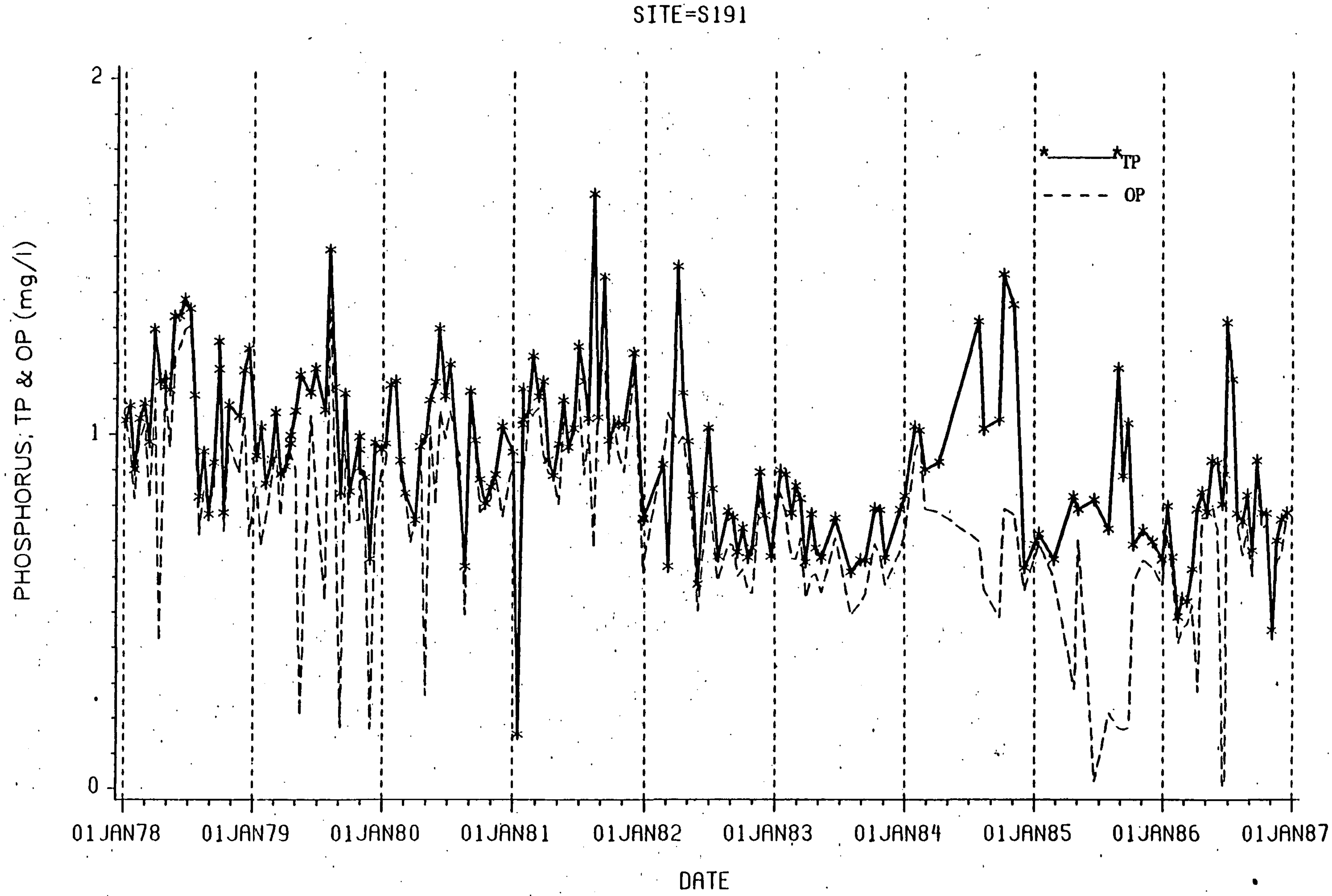
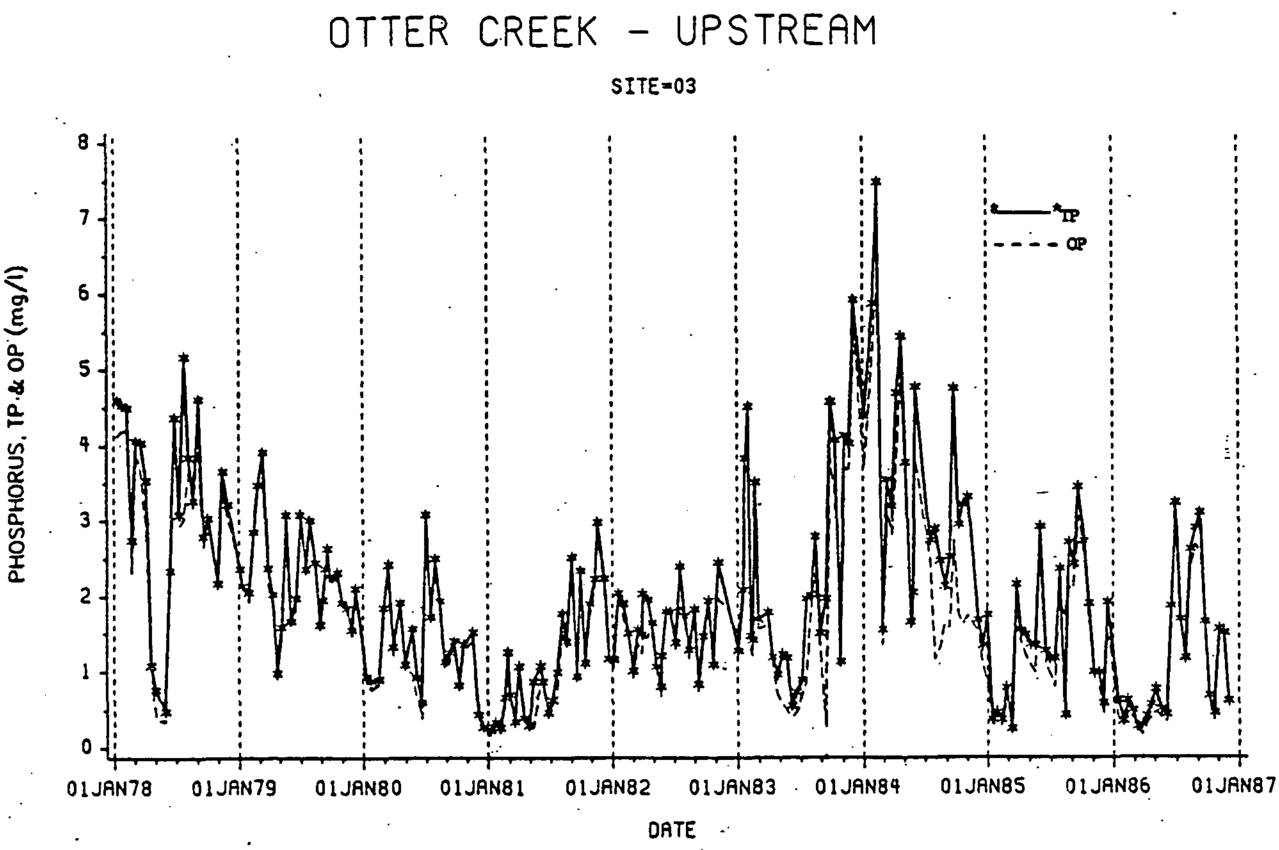


Figure 5.2 Total Phosphorus and Orthophosphate Concentrations for Station S191, the Outflow to Lake Okeechobee



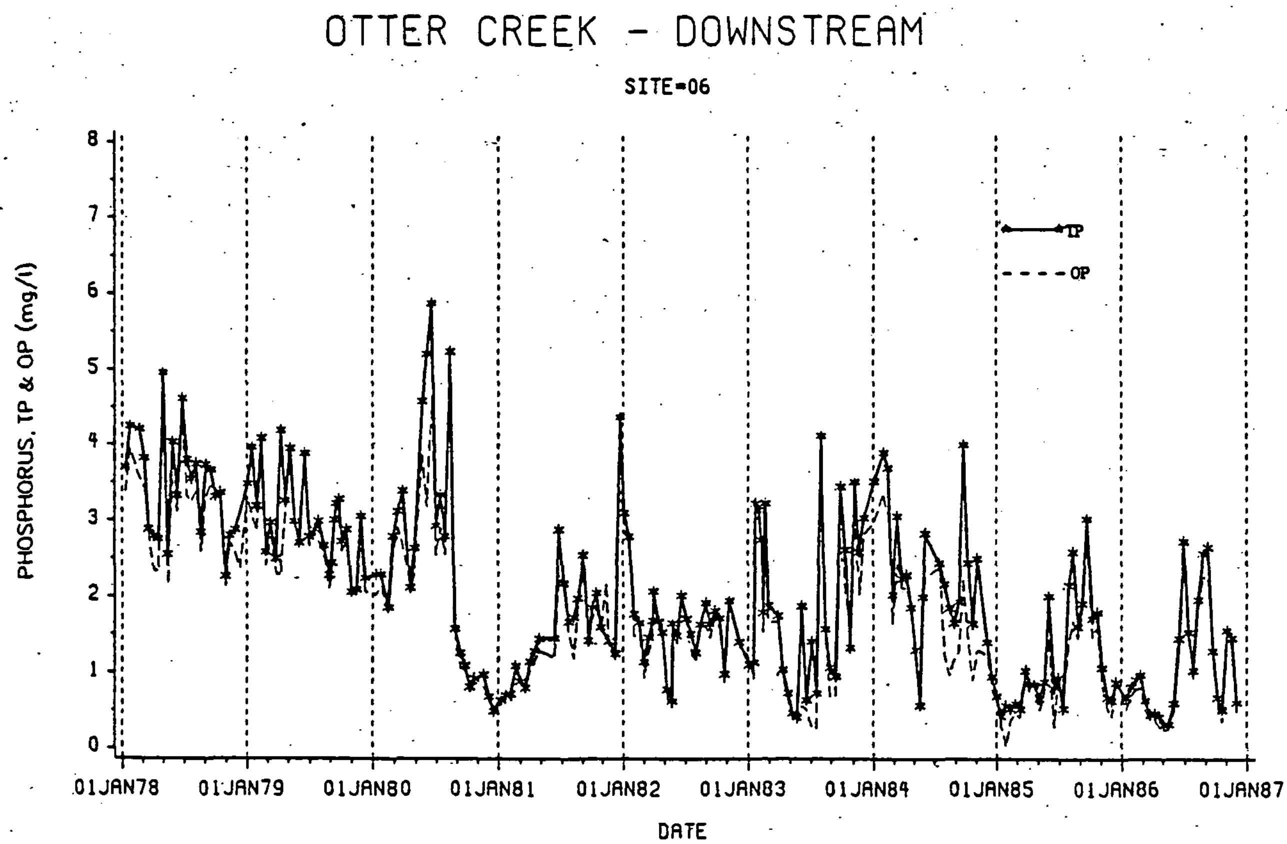


Figure 5.3 Total Phosphorus and Orthophosphate Concentrations for the Upstream/Downstream Otter Creek Water Quality Stations.

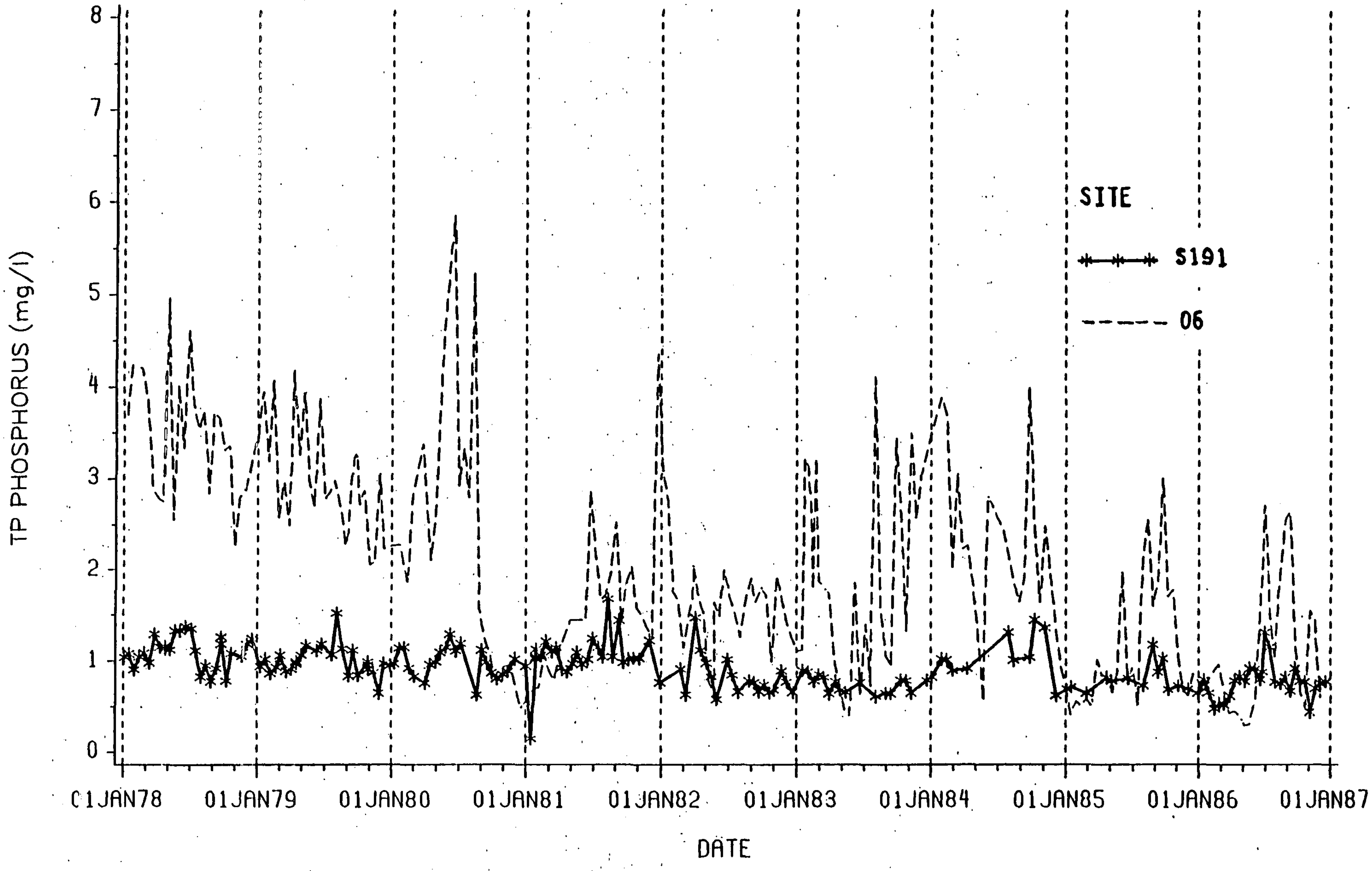


Figure 5.4 Total Phosphorus for Station S191 and Downstream Otter Creek Station 06 from 1978 to 1986.

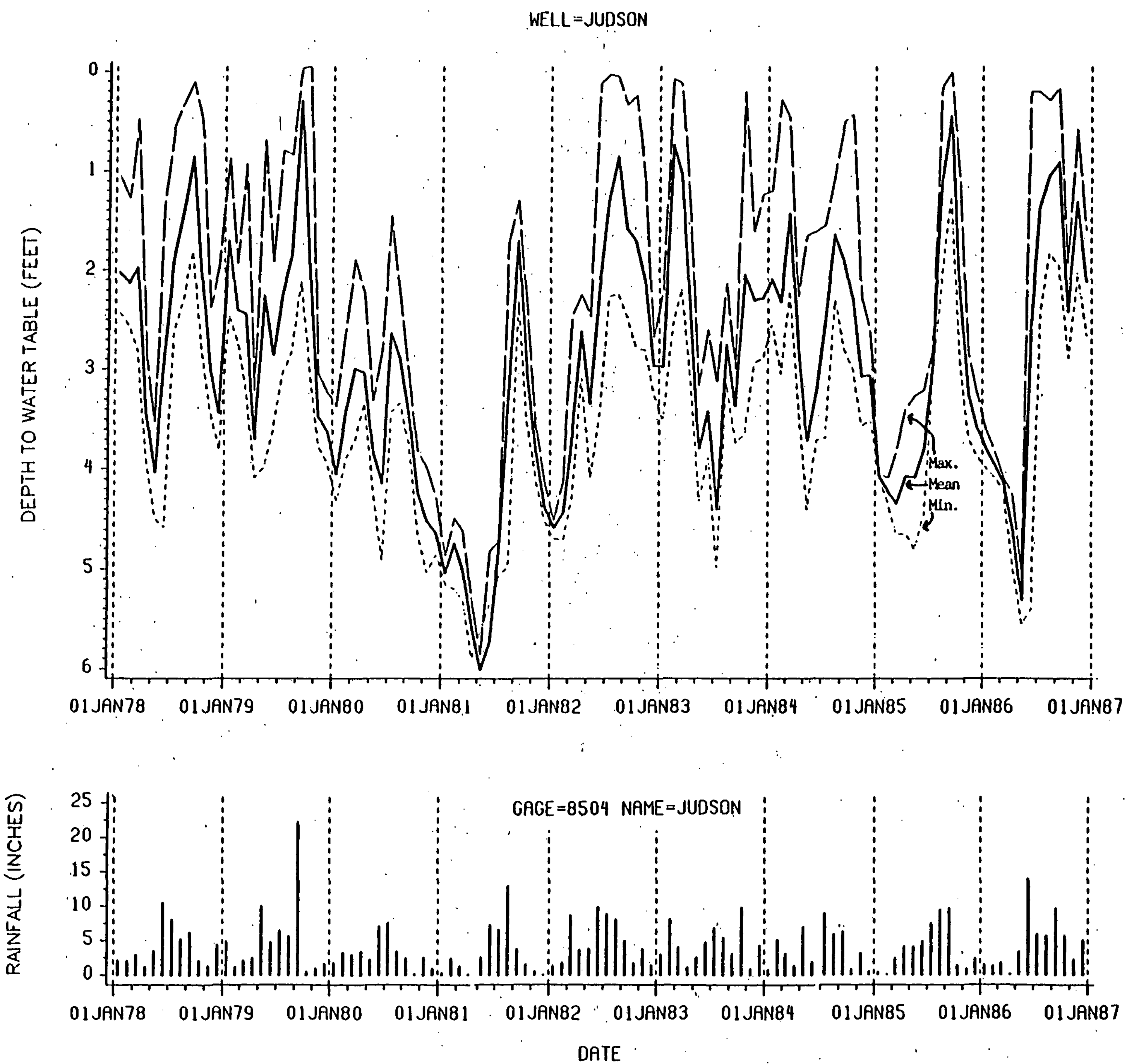


Figure 5.5 The Monthly Minimum Mean, and Maximum Water Table Depth for the Judson Well Water Gage. Total Monthly Precipitation at this Site is also shown. This is in close proximity to water quality stations 03, 06, and 23.

The MDC for each of the water quality monitoring stations determined from the variability in the data is shown in Table 5.3. It should be noted that these MDC values were calculated for the biweekly sampling design and are expressed as a percent change over all years considered. MDC calculated in this fashion is not a yearly value, but a function of the number years monitored. The autocorrelation term was used in all models including covariate models with meteorological and hydrological indexes. Seasonality decreased the MDC values at some stations; seasonality was a statistically significant covariate at stations S191, 11, 18, and 09. The water table depth covariate was significant at all stations where data were available and decreased the MDC at all sites except station 23. The addition of the precipitation covariate was significant only at stations 06 and 23, and was not as effective as the ground water table variable in decreasing the MDC values. Adjustments for these variables should allow for a more meaningful comparison between years with varying amounts of precipitation.

Table 5.3 Minimum Detectable Change Required in the Initial Geometric Mean Concentration of Total Phosphorus at Each Water Quality Monitoring Station over a 9 Year Monitoring Scheme. All data were adjusted for autocorrelation.

Tributary (Station)	Covariates: None	Seasonality	Water Table Depth	Precip.	Water Table Depth & Precip.	Upstream Conc.	Water Table Depth & Upstream Conc.
	Percent Decrease						
Henry(39)	54	53	.	.	.	.	.
Little Bimini(02)	54	47	.	.	.	.	.
Lettuce Creek(40)	66	59	.	.	.	.	.
Mosquito Creek(13)	28	28	.	.	.	15*	.
Mosquito Creek(15)	27	28	.	.	.	.	.
Nubbin-Slough(14)	25	25	.	.	.	27	.
Nubbin-Slough(17)	35	35	.	.	.	.	.
N.W. Taylor Cr.(01)	37	33	32*	33	31*	.	.
L. Okeechobee(S191)	11	10*	.	.	.	.	.
Otter Creek(03)	41	40	29*	40	29*	.	.
Otter Creek(06)	32	31	25*	32*	25*	19*	19*
Otter Creek(23)	50	49	51*	49*	49*	.	.
Taylor Creek(11)	32	28*	27*	29	27*	.	.
Taylor Creek(18)	39	35*	.	.	.	.	.
Williamson Dt.(09)	35	29*	33*	33	32*	.	.

* The covariate (s) was significant in the regression model. In the case where both water table depth and precipitation were covariates, both covariates were significant for all stations examined except stations 01 and 09 where the precipitation covariate did not add significant information to the models.

The use of an upstream covariate was statistically significant and decreased the MDC value substantially at the downstream stations 13 and 06, however, this was not the case at station 14. The upstream concentrations represent incoming pollutant concentrations from natural and agricultural sources upstream from agricultural areas where BMPs are implemented.

Relatively small MDC values were obtained for site S191. This may be due to buffering capacity, inertia, or ponding effects at this station. S191 represents a large watershed. Although the MDC values may be relatively small, the time to achieve a significant change will not only depend on the amount of effective land treatment, but also on the amount of buffering capacity in the water system at this site. In contrast, first order stream sites such as 23, 39, 40, 02 exhibited high variability in the TP measurements and have relatively high MDC values. It appears that the variability of the measured observations, and therefore the MDC, is a function of several factors including watershed size, land use, hydrology, and meteorology.

The magnitude of observed changes (after adjustment for covariates) in TP measured from 1978 to 1986 was calculated and compared to the calculated MDC values. The observed change was expressed as a percent change in the predicted geometric mean value from 1978 to 1986 relative to the predicted geometric mean value in 1978 (Table 5.4). Tests for significant changes over time (i.e. changes greater than MDC) at each station were performed and are reported in Table 5.4. The direction and significance of the linear trends are summarized in Table 5.5.

Table 5.4 The Percent Change in Predicted Geometric Mean Values from 1978 to 1986 Measured at the Water Quality Monitoring Stations After Adjustment for the Appropriate Covariates.

	Covariates						
Tributary (Station)	None	Seasonality	Water Table Depth	Precip.	Water Table Depth & Precip.	Upstream Conc.	Water Table Depth & Upstream Conc.
	Percent Decrease						
Henry Creek(39[1])	67*	67*	.	.	.	.	.
Little Bimini(02)	-30	-29	.	.	.	.	.
Lettuce Creek(40[1])	55	53	.	.	.	.	.
Mosquito Creek(13)	-36*	-36*	.	.	.	-13	.
Mosquito Creek(15)	-51*	-51*	.	.	.	.	.
Nubbin-Slough(14)	27*	27*	.	.	.	21	.
Nubbin-Slough(17)	262*	256*	.	.	.	.	.
N.W. Taylor Cr.(01)	63*	64*	55*	65*	54*	.	.
L. Okeechobee(S191)	-29	-29	.	.	.	.	.
Otter Creek(03)	-43*	-43*	-41*	-42*	-41*	.	.
Otter Creek(06)	-69*	-69*	-68*	-69*	-68*	-62*	-62*
Otter Creek(23[2])	-16	-17	-27	-19	-21	.	.
Taylor Creek(11)	-38*	-38*	-36*	-38*	-36*	.	.
Taylor Creek(18[2])	-37	-40*	.	.	.	.	.
Williamson Dt.(09)	-21	-21	-12	-21	-10	.	.

1. Percent change calculated from available 1981 to 1986 data (6 years).
2. Percent change calculated from available 1979 to 1986 data (8 years).
* Observed changes were sufficient to be statistically significant.

Table 5.5 Linear Trends Over 9 Years for the TP Concentrations Measured at the Water Quality Monitroing Stations.

Tributary	Station	Significance of Trend	Direction of Trend
Henry Creek	39	+	Increasing
Little Bimini	02	ns	-
Lettuce Creek	40	ns	-
Mosquito Creek	13	*	Decreasing
Mosquito Creek	15	**	Decreasing
Nubbin-Slough	14	ns	-
Nubbin-Slough	17	**	Increasing
N.W. Taylor Creek	01	*	Increasing
Lake Okeechobee	S191	**	Decreasing
Otter Creek	03	+	Decreasing
Otter Creek	06	**	Decreasing
Otter Creek Trib.	23	ns	-
Taylor Creek	11	*	Decreasing
Taylor Creek	18	*	Decreasing
Williamson Ditch	09	ns	-

\+ Significant at the P=.1 level
* Significant at the P=.05 level
* Significant at the P=.01 level
ns Not significant

It should be noted that this project has had a high rate of BMP implementation, most of which occurred in 1985 and 1986. Thus, a very extensive pre-BMP water quality data base exists for statistical comparison with post-BMP data.

Phosphorus concentrations in Otter Creek decreased significantly. However, there is strong evidence that two dairy closures (in 1981 and 1985) in that subwatershed may be the cause of this trend (Ritter and Flaig, 1987). Data from Mosquito Creek, a subwatershed with intensive BMP implementation, also show a significant decrease in TP (Ritter and Flaig, 1987). In contrast, increased animal densities and use of animal feeds with high P concentrations appears to have degraded water quality in the N.W. Taylor Creek subwatershed (Ritter and Flaig, 1987).

At station S191, the watershed outlet, an overall decreasing trend in TP concentrations is shown. The project postulates that this trend is largely a function of the dairy closures in the Otter Creek subwatershed and the large number of BMPs implemented in the Mosquito Creek subwatershed. Fencing, manure management, and fertilizer management are thought to be significant practices related to decreasing total phosphorus concentration. It should be noted that the majority of BMP implementation did not occur until 1985, 1986, and 1987, so major improvements may not be documented until a few years of post-BMP data is collected.

CONCLUSIONS

Water quality monitoring data from the Taylor Creek - Nubbin Slough RCWP agricultural NPS control project were examined for significant trends in TP and OP. The statistical analysis employed calculation of the minimum detectable change (MDC) required to say with confidence that changes in pollutant concentrations over time were real. The MDCs for TP at monitoring stations in this NPS project range from 10 to 59 percent after adjustments for precipitation, seasonality and ground water level. MDC was found to be a function of subwatershed size and variability in covariates such as antecedent precipitation, ground water levels, season (wet or dry), and upstream concentrations.

We found that three subwatersheds as well as the outflow from the project area show real decreasing trends for TP (P = .05). These trends appear to be related to land treatment under RCWP and dairy closures. RCWP is a 10-year experiment and the project should be able to document further significant decreases in TP concentrations over time.

There are many confounding factors in water quality analysis and it is difficult to identify and account for all of them. However, by using the MDC, it is possible to evaluate with confidence real changes in pollutant concentrations over time. This technique can contribute to improved analysis of the effectiveness of NPS control efforts.

LITERATURE CITED

Allen, L.H., Jr., J.M. Ruddell, G.J. Ritter, F.E. Davis, and P. Yates. 1982. Land use effects on Taylor Creek Water Quality. Pages 67-77 In Proc. Specialty Conference on Environmentally Sound Water and Soil Management. American Society of Civil Engineers, New York, New York.

Bell, F.W. 1987. Economic Impact and Valuation of the Recreational and Commercial Fishing Industries of Lake Okeechobee, Florida. Department of Economics, Florida State University, Tallahassee, Florida.

Canfield, D.E., Jr. 1988. The Eutrophication of Lake Okeechobee: An Alternative Viewpoint. J. Lake and Reservoir Management, Volume 4.

Frederico, A.C., K.G. Dickson, C.R. Kratzer, and F.E. Davis. 1981. Lake Okeechobee water quality studies and eutrophication assessment. Tech. Pub. 81-2. South Florida Water Management District, West Palm Beach, Florida. 270 pp.

Heatwole, C.D., A.B. Bottcher, and L.B. Baldwin. 1986. Basin Scale Model for Evaluating Best Management Practice Implementation Programs. Trans. of the ASAE. 29(2):439-444.

Heatwole, C.D., A.B. Bottcher, and L.B. Baldwin. 1987a. Modeling Cost-effectiveness of Agricultural Nonpoint Pollution Abatement Programs on Two Florida Basins. Water Res. Bull. 23(1):127-131.

Heatwole, C.D., A.B. Bottcher, and K.L Campbell. 1987b. Basin Scale Model Water Quality Model for Coastal Plain Flatwoods. Trans. of the ASAE. 30(4):1023-1030.

The Lake Okeechobee Technical Advisory Committee (LOTAC). 1986. The Overall review of South Florida Water Management District Lake Okeechobee Research Final Report to South Florida Water Management District. Arthur D. Little, Inc.

Ritter, G.J. and E.G. Flaig. 1988. Water quality report: 1987 Annual report, Rural Clean Water Program. Technical Memorandum. South Florida Water Management District, Water Quality Division. West Palm Beach, Florida. 71 pp.

SAS Institute, Inc. 1985a. SAS User's Guide: Basics, Version 5 Ed. Cary, NC: SAS Institute Inc. 1290 pp.

SAS Institute, Inc. 1985b. SAS/ETS User's Guide, Version 5 Ed. Cary, NC: SAS Institute Inc. 738 pp.

Spooner, J., R.P. Maas, M.D. Smolen, and C.A. Jamieson. 1987. Pages 243-257, In Symposium on Monitoring, Modeling, and Mediating Water Quality. American Water Resources Association.

Stanley, J., V. Hoge, and L. Boogs. 1986. Taylor Creek-Nubbin Slough Project Rural Clean Water Program Annual Progress Report. Okeechobee County, Florida.

ACKNOWLEDMENTS

The authors would like to acknowledge the following persons for their help on this chapter: Dr. David A. Dickey, Department of Statistics, North Carolina State University; Gary Ritter and Eric Flaig, South Florida Water Management District; Lynn Hester, USDA-SEA-AR, Southeast Watershed Research Laboratory, Tifton, Georgia.