Final Report
Neuse Crop Management Project

September 16, 1998 – September 30, 2002

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Executive Summary

The Neuse River Basin drains 1.2 million acres in central and eastern North Carolina (NC), including rapidly growing metropolitan areas, productive farmland, and extensive forests. The Neuse River Estuary has experienced harmful algae blooms and fish kills over the past two decades, resulting in state regulations that mandate a 30% reduction in annual nitrogen loading from all sources by 2003. Agricultural land uses throughout the river basin are estimated to contribute more than half of the total nitrogen load to the estuary, meaning that farmers are responsible for implementing best management practices that reduce nitrogen export by over 1 million pounds annually. At the same time, pesticides used in the region are under intense scrutiny by the US Environmental Protection Agency as it implements the Food Quality Protection Act.

The Neuse Crop Management Project was initiated in 1998 with the goal of increasing the use of production practices that improve the economic, agronomic, and environmental performance of corn/cotton/wheat/soybean farmers in the Neuse River Basin. The project established an unprecedented partnership among farmers, crop consultants, agribusinesses, grower organizations and NC State University research and extension to reduce unnecessary nitrogen and herbicide use and losses, thereby protecting water resources in the Neuse River Basin.

The Neuse Crop Management Project, along with the many other agencies and producers working in the Neuse River Basin, has accomplished its goal of enabling farmers to improve water quality, effectively deal with public and regulatory concerns, and sustain economic viability. Specific accomplishments of the comprehensive education and research efforts include:

- more than 105,000 acres of nutrient management plans;
- a 23% reduction in the amount of fertilizer nitrogen applied per acre of cropland; and
- a greater than 40% reduction in soil-applied preemergence herbicides;

Nutrient management training materials were developed and distributed to NC Cooperative Extension Service county agents, who then educated farmers about nutrients in the environment, how best management practices reduce nutrients, nutrient management planning and eight crop commodity modules. In 2001 and 2002, nutrient management training was offered throughout the Neuse River Basin to 1,240 farmers and turf managers.

Nutrient management planning was a major effort in the project to meet the goal of increasing the use of economic and environmentally sound production practices. Project staff worked directly with cooperating farmers from 1999 to 2002 to write and implement nutrient management plans. By 2002, nutrient plans had been developed for over 105,000 acres of cropland. To meet the challenge of developing nutrient management plans for thousand of acres, project personnel developed two innovative approaches. A simplified computerized nitrogen fertilizer spreadsheet was developed for commercial fertilizer plans. In addition, group nutrient management planning sessions were introduced. The farmers brought field information and project personnel worked with the farmers to write nutrient management plans.

The Neuse Crop Management Project installed complete systems of best management practices on several farms using funding provided by the NC Clean Water Management Trust Fund. Additional practices beyond nutrient management planning included grassed waterways, field borders, sod-based rotations, and flashboard risers (controlled drainage).

On-farm demonstrations were established in four areas within the Neuse River Basin to demonstrate and evaluate effective best management practices for each physiographic region in the

basin. In addition, the project team developed a series of small demonstrations in eight counties throughout the river basin to promote local adoption of nutrient management planning. These plots demonstrated that nutrient rates recommended by state agencies and NC State University did not reduce yield goals. Twelve field days were held at the demonstration farms to provide opportunities for commodity suppliers, farmers and agency personnel to view project activities at demonstration sites.

Two cost-benefit analyses were conducted during the life of this project. One analysis was for the best management practices, such as controlled drainage, cover crops and buffers, and the other was for nutrient management. The nutrient management cost-benefit study found that many farmers can save $20-40 per acre of cropland by using nutrient management. The best management practice cost-benefit analysis found that the benefit of the best management practices was highly dependent on the practice and the physiographic region.

To help producers make better herbicide use choices, and thus reduce preemergent soil-applied herbicides, the project selected to use a computer-based decision support system called HADSS (Herbicide Application Decision Support System) that allows farmers, commodity specialists, or crop consultants to determine the most cost-effective, environmentally sensitive, and effective herbicide. By making decisions on a field-by-field basis (termed site-specific), more precise selection of herbicides, application rates, timing, and placement of weed control measures are possible, and can minimize the application of unnecessary or inappropriate herbicide treatments. During the project, however, the weed control situation changed dramatically when Roundup Ready technology was introduced to NC farmers. Growers quickly embraced the Roundup Ready system for cotton and soybeans. In 2002 over 90% of the soybean acreage and upwards of 60% of the cotton acreage are in Roundup Ready varieties. Using acreage data on corn and shifts into Roundup Ready varieties, one can conservatively estimate a 40% decrease in the use of soil-applied preemergence herbicides. The rapid acceptance and increase in soybean and cotton acreage of Roundup Ready crops has dramatically accelerated the reduction in soil-applied preemergence herbicides.

The project was extremely cost effective. In 2002, nutrient management plans were written on 105,099 acres. The commercial rate for nutrient management planning is $8.00 per acre. Had the commercial rate been charged, the project would have spent the majority of the funding received from the Center for Agricultural Partnership on only nutrient management planning. As a result of the cost effectiveness of the project, many other educational and promotional activities occurred, including the HADSS work. The project also supported critically important needs that were not sufficiently funded through the state budget:

- Development of training materials for the mandated nutrient management education program
- Computerization of the best management practice accounting and tracking tool – Nitrogen Loss Estimation Worksheet (NLEW)
- Computerization of the new tool – Phosphorus Loss Assessment Tool (PLAT) – needed to meet new USDA-Natural Resources Conservation Services nutrient management standards
- Development of the commercial fertilizer computerized spreadsheet used in developing nitrogen fertilizer plans

The Neuse Crop Management project demonstrated that nitrogen management is an effective and cost-efficient means for controlling nonpoint source nitrogen from agricultural sources. Before the project, many producers used their soil tests for lime, not phosphorus, and they applied nitrogen at standard rates. Two-thirds of the participating growers reported that they decreased their nitrogen application rates as a result of project recommendations. Some examples of estimated nitrogen rate

reductions due to the project are 15 to 20% on cotton, 14 to 28% on corn, 15 to 24% on tobacco, and 4 to 20% on wheat. One farmer stated, “The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work.”

The project’s success was based on a unique set of circumstances: the existence of the Neuse Education Team and the many other agencies and organizations working in the Neuse River Basin; the extensive consultation and feasibility study at the beginning of the project which led to the creation of strong working relationships that made the project successful on a very significant scale; the ability to obtain funding from multiple sources; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project structure; the willingness of the farmers to be part of the solution, having project technicians that allowed intensive, one-on-one work with growers; an egalitarian structure that allowed staff to make decisions and do their work relatively independently; and the regulatory pressures for nitrogen reduction.

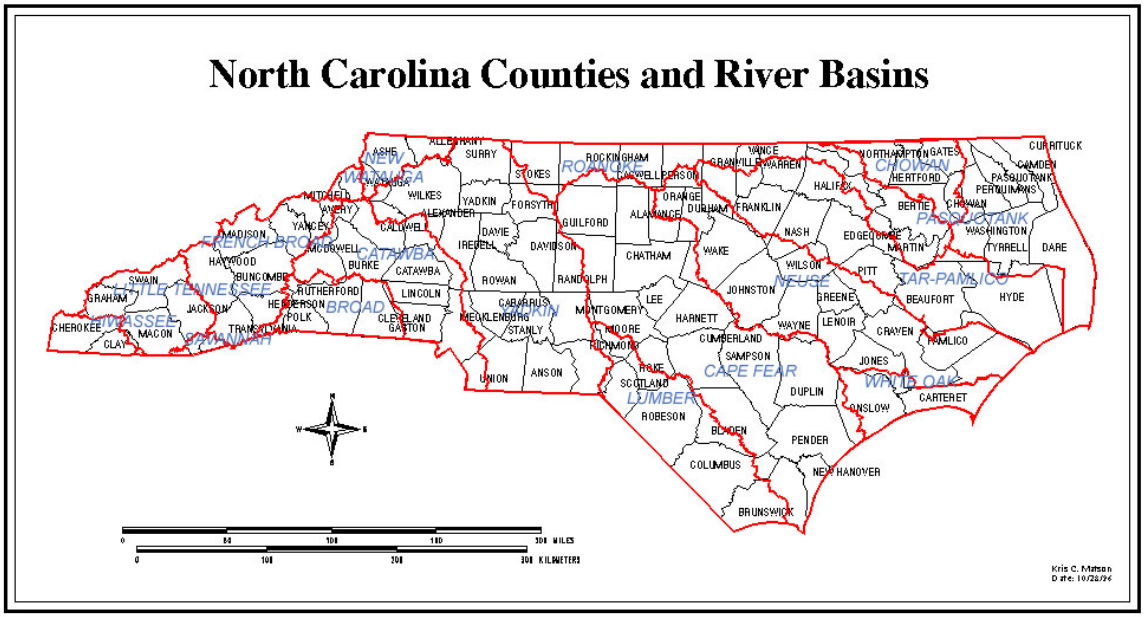
One of the advisory board members, who is also a farmer, summarized the project, "This project provides an opportunity for farmers to provide leadership in implementing solutions to solve regional problems" — *Charles Alexander, Pamlico County producer*. Based on the successes of the Neuse Crop Management Project, the project helped the agricultural community exceed its goal of a 30% nitrogen reduction in the Neuse River Basin. With the agricultural sector documenting a 34% nitrogen reduction in 2002, Mr. Alexander’s words have come true: the farmers provided leadership in implementing the solutions along with many competent and hard working agribusiness personnel and state and federal agency employees.

Chapter 1: Introduction

The Neuse Crop Management Project focused on input reductions of nitrogen and preemergent herbicides on agricultural cropland in the Neuse River Basin. This project was a direct response to state regulations and a federal Total Maximum Daily Load (TMDL) standard requiring a 30% reduction in nitrogen from all sources, including the agricultural community (NC Department of Environment and Natural Resources, 1997). Although the amount of herbicide detected in water resources in North Carolina is low, reducing unnecessary herbicide applications seemed prudent. The project was designed to involve multiple stakeholders, including agribusiness interests, state and federal agency personnel, university extension professionals, commodity organizations, and most especially, the farmers themselves.

Neuse River Basin: Problems and Regulations

The Neuse River in central and eastern North Carolina flows over 200 miles from its headwaters in the Piedmont near Durham through the Coastal Plain and into the Pamlico Sound east of New Bern (Figure 1.1). The Neuse River Basin is a unique and sensitive environment, featuring high water tables, abundant wildlife, and over one million acres of highly productive cropland in close proximity to streams and drainage ditches. The river was classified by the North Carolina Environmental Management Commission as Nutrient Sensitive Waters in 1988 because of excessive algal production and fish kills in the Neuse River Estuary. This classification resulted in mandatory controls on nutrient point source discharges and financial incentive programs to reduce nonpoint sources of nutrients from agriculture.



After several major fish kills in the 1990s, new regulations, known as the "Neuse Rules" were implemented in 1998 with the goal of reducing annual nitrogen loading in the estuary from all sources by 30% by 2003. Approximately half of the Neuse River's nitrogen pollution has been attributed to agricultural operations, including cropland, pasture, and confined animal operations.

Under the "Neuse Rules" agricultural farmers were required to either implement standard best management practices or participate in a county-level area plan. The four choices in standard best

management practices were (1) a 50-foot forested riparian buffer, (2)nutrient management and a 30-foot vegetative buffer, (3) nutrient management and a 20-foot forested buffer, or (4) nutrient management and controlled drainage. Under the county-level management plan, farmers in the county were required to collectively achieve a 30% nitrogen reduction by implementing sufficient types and amounts of best management practices. These best management practices consisted of nutrient management, controlled drainage, buffers of different types and widths, and cover crops. To account for the county-level nitrogen reductions, a best management practice tracking and accounting tool, which had not yet been developed, was legislated. The tool developed for this accounting process was the Nitrogen Loss Estimation Worksheet (NLEW), details of which are found in Appendix A (Osmond et al., 2000a & b).

Using Education to Help Solve the Problem in the Neuse

Understanding that the five year, 30% nitrogen-reduction goal was very ambitious, the North Carolina General Assembly initiated the Neuse Education Team in 1996 by providing special funding to address environmental education needs in the river basin. The Neuse Education Team is part of the NC Cooperative Extension Service at NC State University. This unique team comprises four Area Extension Agents and four campus-based Extension Specialists. The objective of the Neuse Education Team is to increase local understanding of how specific technologies can be used to protect water quality and to promote local adoption of effective nutrient-reducing best management practices. Additional information about the team and its activities can be found at http://www.neuse.ncsu.edu/ (Appendix B).

Since 1997, the Neuse Education Team has worked with farmers and agricultural support organizations to develop specific educational programs to meet local needs. It became immediately clear that significant resources would be necessary to implement comprehensive local programs to improve water quality. In 1997, the Center for Agricultural Partnerships began an effort to determine what was necessary to help farmers meet the environmental challenges they faced and to assess whether this effort could be successful. Meeting with growers, crop consultants, Cooperative Extension staff, dealers, and grower associations, the Center for Agricultural Partnerships sought to determine the best course of action to help farmers make necessary and effective changes in their production practices.

In the summer of 1997, a meeting with more than 40 people representing growers, commodity organizations, private sector, and NC State University was held in Kinston, North Carolina. The intent of the meeting was to identify the project's target areas: nutrient and weed management. Building on the Neuse Team's agricultural strategy for best management practice education and implementation for producers in the Neuse River Basin, the Center for Agricultural Partnerships hosted a dozen representatives from the Kinston group, in addition to the Neuse Education Team, to develop a more comprehensive project strategy that also included greater representation from the entire agricultural community and weed management strategies. The Center for Agricultural Partnerships, along with Neuse Team members, worked throughout the next year to develop a work plan and an approach that would bring together everyone who had a role to play and a stake in reducing the impacts from agriculture in the Neuse River Basin.

In the fall of 1998, the Center for Agricultural Partnerships initiated the Neuse Crop Management Project with support form the Pew Charitable Trust and the US Environmental Protection Agency (Table 1.1). The goal was to help farmers identify and implement economically sound farming practices to sustain productivity while meeting environmental obligations. The project established an unprecedented partnership among farmers, crop consultants, agribusinesses, grower organizations, and NC State University research and extension to reduce unnecessary nitrogen and

herbicide use and losses, thereby protecting water resources in the Neuse River Basin. The collaboration continued throughout the project from the development of the work plan at the beginning of the project during an all-day session in Goldsboro through annual project meetings, midterm assessments, and final evaluations.

Designed to fill a critical funding role in improving water quality in the Neuse River Basin, the project was able to take advantage of other important efforts in the Neuse that dealt with different but very complementary facets of the solution. The NC Clean Water Management Trust Fund, which provided a grant of $329,520, supported additional aspects of the Neuse Crop Management Project: best management practice implementation, equipment purchases, and water quality monitoring on the demonstration farms. The North Carolina Department of Environment and Natural Resources provided funding totaling $210,000 to support a producer best management practice survey in the basin. As part of the larger US Environmental Protection Agency 319 project, an initial baseline survey of fertilizer rates was conducted. In addition, the project could not have been successful without countless hours of donated time provided by cooperating farmers, agribusiness representatives, and concerned citizens throughout the Neuse River Basin.

A member of the Neuse Education Team, Deanna Osmond, based at NC State University, provided the overall management of the Neuse Crop Management Project. Other team members (David Hardy, Bill Lord, Mike Regans, and Steve Hodges), as well as a county-level Extension Agent (Bob Pleasants), provided management of the demonstration farms and work with area farmers. Neuse Education Team salaries and operating expenses are supported through funding provided by the North Carolina General Assembly since 1996. The team produces the quarterly NeuseLetter with a feature column on the Neuse Crop Management Project (Appendix E).

Mike Linker, a member of the Crop Science Department at NC State University, along with a post-doctoral student, provided leadership for the herbicide portion of the project. Additional funding provided by the UNC Water Resources Research Institute and by NC State University supported several Soil Science Department graduate students, whose research is critically important to information developed by this project.

The project's first year was marked by severe drought and natural disaster. During the 1999 growing season, an intense drought stunted plant growth and precluded nitrogen response in crops. Then in September more than 20 inches of rain from Hurricane Fran fell on the region in a matter of days, causing extensive flooding and damage, only to be followed by another hurricane a few weeks later. As a result the project was extended for an additional year to ensure that data from three full growing seasons would be available. Because of extensive consultation and involvement of the key people and organizations necessary for success and a focus on the implementation of environmentally sound practices, the Neuse Crop Management Project was uniquely able to complement other efforts to craft significant and lasting changes in the basin.

The project's success, as determined by the final evaluation (see Appendix D), was based on the following unique set of circumstances: the ability to obtain complementary funding; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project structure; the willingness of the farmers to be part of the solution; and the regulatory nature of the problem being addressed.

The Neuse Crop Management Project was one part of a much greater research effort in the Neuse River Basin. This very large effort to reduce agricultural nitrogen loads by 30% could not have been met without the extraordinary efforts of many agencies, groups, and individuals. These groups include the Neuse River Basin Oversight Committee, the NC Department of Environment and

Natural Resources (Division of Water Quality, and Division of Soil and Water Conservation), NC Farm Bureau Federation, the Neuse River Foundation, Soil and Water Conservation Districts, the Neuse Technicians (funded under the Division of Soil and Water Conservation), county Cooperative Extension Agents in the basin, USDA-Natural Resources Conservation Service, and most especially the producers themselves.

Table 1.1 Funding for the Neuse Crop Management Project

Funding Organization	Funded Item	Funding
Pew Charitable Trust & US Environmental Protection Agency through the Center for Agricultural Partnerships	Project coordinator and technicians	$867,000
	Nutrient management training	
	Software production (NLEW & PLAT)	
	Economic analysis of best management practices	
	Nutrient management planning and implementation	
	Communications	
	Project evaluation	
	Field days	
	Project logistics and material	
NC Clean Water Management Trust Fund	BMP implementation (controlled drainage & sediment-reducing practices)	$329,520
	Water quality monitoring	
	Equipment	
UNC Water Resources Research Institute	Graduate stipend	$60,000
	Water quality monitoring	
	Travel	
NC Cooperative Extension Service – NC State University	Project personnel – 3 Neuse Education Team members and a county agent provided management of the demonstration farms and local direction of farmer education programs. The NeuseLetter was produced by the team.	$800,000
US Environmental Protection Agency 319 – NC Department of Environment and Natural Resources	Sample selection	$210,000
	Sampling maps	
	Data collection	
	Data analysis	

Chapter 2: Project Objectives

The goal of the Neuse Crop Management Project was to significantly increase the use of production practices that improve economic and environmental performance in the Neuse River Basin. The successful accomplishment of this goal enabled farmers to adopt agronomically and economically sound practices to protect water quality and effectively deal with public and regulatory concerns. The project focused on herbicide and fertilizer practices for corn, cotton, wheat, and soybeans, which account for 84% of planted farmland acres in the Neuse River Basin. Targeted and efficient use of nutrients and herbicides is critical to both cost-effective crop production and water quality protection in the Neuse River.

The specific project objectives focused on implementing best management practices.

> Objective 1. Implement nutrient management and weed integrated pest management practices on 100,000 acres of cropland in the Neuse River Basin.
>
> Objective 2. Implement weed integrated pest management to achieve a 10-30% reduction in the use of soil-applied preemergence herbicides on the project acreage (primarily alachlor, acetochlor, metolachlor, pendimethalin, vernolate, simazine, cyanazine, trifluralin, and atrazine).
>
> Objective 3. Implement nutrient management practices to achieve 10-20% reductions in the use of nitrogen on the project acreage.

Project outcomes, as measured against project objectives, were met for all three objectives.

> Objective 1. More than 100,000 acres of nutrient management and weed pest management practices were implemented (Table 3.1)
>
> Objective 2. As a result of crop shifts from corn to cotton (25% reduction in corn) and the dramatic increase in the use of Roundup Ready soybeans and cotton (to over 75% of these crops), the use of preemergence herbicides was reduced. Based on the increase in Roundup Ready soybeans or cotton and the decrease in corn acreage, one can conservatively estimate a 40% decrease in the use of soil-applied herbicides.
>
> Objective 3. Based on information using the Nitrogen Loss Estimation Worksheet (Appendix A), overall application rates of nitrogen fertilizer were reduced by 23% (Table 3.2).

Chapter 3: Management Strategy 1 — Best Management Practice Implementation

To accomplish the objectives listed in Chapter 2, the project advisory board team (see Chapter 4) developed four management strategies as follows:

> Management Strategy 1: Demonstration and Implementation. The project team used nutrient management planning, the Herbicide Application Decision Support System, and a series of demonstration farms to encourage widespread adoption of best management practice systems by farmers.
>
> Management Strategy 2: Partnerships and Communication. The project team developed basinwide partnerships and communication strategies to promote the adoption of best management practices throughout the Neuse River Basin.
>
> Management Strategy 3: Nutrient Management Training. The project team developed resource materials and conducted extensive training programs to improve the understanding among farmers and agribusiness professionals of nutrient management, water quality protection, and best management practice impacts.
>
> Management Strategy 4: Evaluation. Evaluations to determine the effectiveness of project efforts toward the adoption of nutrient, herbicide, and other best management practices were made throughout the life of the project.

The project team identified those nitrogen-reducing best management practices appropriate to the physiographic region to address producer needs and developed targeted programs to encourage producer adoption. Much of the project success was due to local technical support provided by project technicians and the development of demonstration farms distributed throughout the river basin.

Nutrient Management Planning

Nutrient management is the careful monitoring and amending of soil fertility to meet the needs of crops with an emphasis on improving agricultural profitability and minimizing impacts on water quality. Although the effectiveness and implementation of other best management practices, such as riparian buffers and controlled drainage, depend on specific site characteristics (drainage, soil, slope), nutrient management is universal and has potential for success regardless of the landscape setting. Fact sheets describing nutrient management planning are listed in Appendix E. Updated information on nutrient management is provided at http://www.soil.ncsu.edu/nmp/.

Nutrient management planning was a major effort in the project to increase the use of economic and environmentally sound production practices. This section describes project staff efforts to write and implement nutrient management plans throughout the Neuse River Basin. It also describes two tools developed for the project: (1) NLEW, which was mandated through the "Neuse Rules" and used to track reductions in nitrogen loss and the implementation of best management practices, and (2) a simplified computerized spreadsheet to aid in nutrient management planning. Lastly, efforts of project staff to address changes in the USDA-Natural Resources Conservation Service 590 Standard for Nutrient Management by developing the Phosphorus Loss Assessment Tool (PLAT) are described. Details of the NLEW and PLAT software packages are described in Appendix A.

Nutrient Management Plans

To reduce nitrogen, the project focused on nitrogen-based nutrient management plans specific to crop needs and soil type. A nitrogen-based nutrient management plan uses the concept of Realistic Yield Expectation to derive the appropriate rate of nitrogen fertilizer. In North Carolina, every soil series and agronomic crop has been assigned a Realistic Yield Expectation for use in writing nutrient management plans that are certifiable under North Carolina standards. The Realistic Yield Expectation is multiplied by a factor specific to each crop and soil combination to derive the appropriate nitrogen fertilization rate.

From 1999 to 2002, project staff worked directly with cooperating farmers to write and implement nutrient management plans. By 2002, nutrient plans had been developed for over 100,000 acres of cropland. Table 3.1 lists county results for cropland acres with implemented nutrient management plans in 2002. In Wayne County alone, over 69,000 acres received nutrient management plans. (See the section on the Wayne County Demonstration Farms for further details on how they accomplished this amount of nutrient management planning.) Primarily project technicians wrote these plans, along with a crop consultant (at one location) funded by the Center for Agricultural Partnerships' portion of the project.

Table 3.1 Cropland Acres with Implemented Nutrient Management Plans (NMP) by County in 2002

County	Acres of NMP written by Neuse Crop Management Project (2002 only)
Carteret	0
Craven*	19,502
Durham	0
Franklin	250
Granville	0
Greene	106.1
Johnston	1,038.2
Jones	0
Lenoir	3007.1
Nash	6,000
Orange	0
Pamlico	0
Person	0
Pitt	0
Wake	2,295
Wayne	72,900.2
Wilson	0
Total	105,098.6

**Plans for this project and a companion project written by Billy McLawhorn*

Using the fields of selected cooperators, project staff determined that nutrient management planning decreased nitrogen use by 10 to 30 pounds per acre, depending on crop, soil, and producer management. This reduction translates to an overall rate reduction of basin nitrogen fertilization on all crops from 87 pounds per acre to 67 pounds per acre, a 23% decrease (Table 3.2). This fertilizer rate reduction coupled with a net decrease in fertilized cropland resulted in a total reduction in the amount of fertilizer nitrogen applied from 76.6 million pounds to 55.9 million pounds, a 27% decrease (Table 3.2). Although the project's nutrient management focus was corn, wheat, soybeans,

and cotton, under the "Neuse Rules," nutrient management plans had to be written for all crops. (These data were collected by the Neuse River Basin Oversight Committee through 2001 and are included in their 2002 report.)

Table 3.2 Changes in Nitrogen Fertilization Rates by Crop for All Counties

Crop	Baseline	2001	Base N	2001 N	Base N	2001 N	Change N lbs	Change N lbs/ac
	(acre)	(acre)	(lb/acre)	(lb/acre)	(lb)	(lb)	(%)	(%)
Corn for grain	177808	102431	160	138	28415464	14131178	-50	-14
Corn for silage	3985	2175	150	128	597395	278810	-53	-14
Soybeans for beans	262696	269197	19	4	4910781	1173420	-76	-77
Cotton	127670	220112	84	71	10768118	15551156	44	-16
Wheat for grain	123036	77385	112	107	13815012	8287573	-40	-5
Tobacco	89642	61159	86	82	7715284	5004770	-35	-5
Bermuda grass	20942	35767	215	182	4497193	6515657	45	-15
Fescue	26632	26988	47	50	1261609	1339940	6	5
Rye	488	154.1	100	100	48720	15381	-68	0
Oats for grain	12374	4983	116	110	1438956	545699	-62	-6
Barley for grain	2358	893	95	91	224523	81589	-64	-4
Sorghum for grain	2290	890	129	110	296429	97707	-67	-15
Peanuts	85	270	10	1	884	344	-61	-88
Soybean-waste	20633	19089	106	120	2194465	2293330	5	13
Sweet potatoes	5666	6867	81	78	457865	533468	17	-4
ALL CROPS	876305	828360	87	67	76642698	55850021	-27	-23

Even though nitrogen was the basis for the plans, soil sample data were used, resulting in a complete nutrient management plan. Generally, farmers could reduce their nitrogen application rates by approximately 15%. In one area, the nutrient management planning process, along with aggressive cotton petiole monitoring, convinced some farmers, who were using poultry litter and fertilizer that they did not have to apply additional commercial fertilizer. This decreased nitrogen applications by as much as 100 lb/acre. Many of the fields sampled required no additional phosphorus and often no potassium. This was reflected in plans with a zero phosphorus and potassium recommendation.

Economic analyses of the outcomes of nutrient management planning indicated that farmers typically could save $20 to $40 per acre by implementing nutrient management (http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-43/fertmgt07-30-021.pdf) (Appendixes E and G). Savings were associated not only with reducing nitrogen, but also by using only as much phosphorus and potassium as soil tests prescribed.

Nutrient Management Demonstrations

The project team developed a series of small demonstrations in eight counties throughout the river basin to promote local adoption of nutrient management planning. Producers were concerned that the use of Realistic Yield Expectations for determining nitrogen fertilization rates would limit yield goals. These plots demonstrated that Realistic Yield Expectations did not limit crop productivity. Locations, crops, and data are included in Appendix F.

BMP Implementation

In conjunction with the Neuse Crop Management Project, the best management practices in Table 3.2 were installed using funding from the NC Clean Water Management Trust Fund. The Wake County Soil and Water Conservation District did much of the work installing the grassed waterways, field borders, critical area plantings, sod-based rotations, wildlife areas, and diversions. Likewise, the Lenoir and Wayne County Soil and Water Conservation Districts were instrumental in the implementation of the flashboard risers (controlled drainage). Personnel from these districts worked with the landowners and sized the structures. The structures in Craven County were implemented by personnel funded through the Center for Agricultural Partnerships portion of the project.

Table 3.3 Acres of Best Management Practices Installed by County

Best Management Practices	County	Acres
Grassed waterways	Franklin/Wake	7.84
Field border	Franklin/Wake	15.01
Diversion	Franklin/Wake	0.77
Critical area	Franklin/Wake	0.24
Sod-based rotations	Franklin/Wake	267.71
Wildlife	Franklin/Wake	2.61
Controlled drainage	Craven, Wayne, Lenoir	3,129

Tracking Nitrogen Reductions (NLEW)

Under the "Neuse Rules," a tracking and accounting tool had to be developed (Appendix A). The tool developed, NLEW, was used to track nutrient management implementation and nitrogen reductions. The conceptual development of NLEW by an interagency committee occurred over a two year period (Osmond et al., 2001a & b). The tool was developed to work at two scales: field level and aggregate. Once the conceptualization was complete, the tool had to be computerized. The computerization was funded by the Center for Agricultural Partnerships and the US Environmental Protection Agency 319 funds.

Since the field-scale version had to account for the over 120,000 fields in the Neuse River Basin with an average field size of less than 10 acres, the aggregate version of NLEW was used to track agricultural nitrogen reductions. Input data for the accounting tool are soil type, crop, field size (acres), nitrogen fertilizer rate (lb/acre), Realistic Yield Expectation for the crop (if known), cover crop type (if grown), use of additional best management practices, such as controlled drainage or buffers (if implemented), and the area that the best management practices affect. The percent total nitrogen reductions due to best management practice implementation (including nutrient management) are compiled in Table 3.4. The percent nitrogen reduction is from the baseline period of 1991-1995. These estimates were compiled by the NC Department of Environment and Natural Resources for a report to the NC Environmental Management Commission in October 2002.

Table 3.4 Estimated Percent Nitrogen Reduction Due To Best Management Practice Implementation

County	Estimated % Nitrogen Loss Reduction
Carteret	45.4
Craven	46.4
Durham	26.4
Franklin	23.7
Granville	23.4
Greene	37.0
Johnston	47.6
Jones	33.9
Lenoir	14.3
Nash	30.2
Orange	19.4
Pamlico	38.5
Person	31.9
Pitt	22.9
Wake	44.7
Wayne	25.1
Wilson	41.6
Total	34.4

USDA-NRCS 590 Nutrient Management Standard, PLAT, and the Neuse River Basin

The Neuse Crop Management Project played an important role as changes were made to the nutrient management standard that the farmers had to implement. The nutrient management standard in the "Neuse Rules" refers to the USDA-Natural Resources Conservation Service 590 nutrient management standard, and as such, must meet these criteria. In 1999, USDA-Natural Resources Conservation Service changed its nutrient management standard 590 to include phosphorus (P) as a limiting nutrient for agricultural nutrient applications. Each state was responsible for developing a procedure to assess phosphorus status during nutrient management planning if animal waste is involved or the field is within an impaired watershed. A North Carolina Phosphorus Committee was formed to address the changes in the USDA-Natural Resources Conservation Service nutrient management policy and standard 590. Each state had three options to set a P-standard: soil test, soil-threshold, and P-Loss Index.

The NC Phosphorus Committee strongly endorsed the P-Loss Index concept. To avoid confusion with the agronomically based NC Department of Agriculture and Consumer Services "P-Index" reported on soil-testing forms, North Carolina will use the term "P Loss Assessment Tool (PLAT)" as the basis for nutrient management planning (Appendix A). Once this new standard was in place, nutrient management was required to meet the new USDA-Natural Resources Conservation Service criteria. Thus it was imperative that this project help develop the necessary tool – PLAT – to ensure that the nutrient management plans written for the Neuse River Basin are certifiable. The Neuse Crop Management Project was proactive in assuring that farmers in the Neuse River Basin would not be penalized by this change in the nutrient management standard USDA-Natural Resources Conservation Service.

HADSS – Herbicide Application Decision Support System

Herbicide Issues

Weeds are essentially a problem in every field every year. So farmers must devise a weed control plan for all crops. Weeds are formidable competitors and well adapted to production systems. For example, many weed species are prolific seed farmers, and seeds can lay dormant for many years (up to 17) and still germinate. Weeds not controlled during the growing season can increase mechanical loss at harvest as well as reduce yield and quality. There are several nonchemical approaches to weed control: rotation, cultivation, cover crops, increased crop density (both within and between rows), and manipulation of planting dates. All of these are practiced to some extent by farmers. Although these approaches lessen weed pressure, none eliminate weeds, so farmers need additional means of direct control. Alternatives to herbicides (e.g., biological control or induced resistance) are not available as they are for insects and plant pathogens. This situation results in herbicides being a fundamental part of controlling weeds.

In the last decade the number of herbicides available for weed control has increased dramatically. For example, in the *1998 Agricultural Chemicals Manual* (NC Cooperative Extension Service), 176 single and herbicide combinations were recommended for cotton weed control. For soybeans it was 136. In 1990, for cotton, there were only 32 single herbicide and herbicide combinations available. Not only is there a bewildering array of choices, but selecting among the choices makes decisions even more complex. Few herbicides could control a wide array of weeds (before Roundup Ready), requiring farmers to apply multiple herbicides. This situation was ripe for misapplications and unnecessary treatments. Additionally, farmers were coming out of what may be termed a "preemergence and preplant incorporated" era of weed control - a time when postemergence herbicides were few and weed control depended on herbicides applied before or just after the crop was planted. The problem with this system was that herbicides were applied before the weed situation was known and the herbicides being used were most often associated with ground and surface water contamination. The challenge was clear: change the system to allow herbicide treatment according to need and provide farmers with a simple way to sort through the array of herbicides available so they will be more amenable to a treat-as-needed system. Regulatory scrutiny of many of the herbicide choices for farmers under the Food Quality Protection Act added an additional and critical imperative to devise and implement practices that minimize herbicide use.

Herbicide Project Activities

To meet the need for a simple way to make complex decisions faculty at NC State University developed a computer-based decision support system called HADSS (Herbicide Application Decision Support System). This system is the result of many years of weed experimentation and software development. The program allows farmers, commodity specialists, or crop consultants to determine the most cost-effective, environmentally sensitive, and effective herbicide. Users enter relevant, field-specific information regarding weed populations, yield expectations, economic variables, and field conditions. HADSS estimates yield loss that may occur if no control methods are used; eliminates herbicide treatments that are inappropriate for the specified conditions; and calculates expected yield loss after treatment and expected net return for each available herbicide treatment. Treatments are initially sorted by expected net return, but they can be sorted in various ways (cost, efficacy against the total weed complex or a particular weed species, etc.). The web version of this program is at http://cropserv3.cropsci.ncsu.edu/webhadss/.

By making decisions on a field-by-field basis (termed site-specific), more precise selection of herbicides, application rates, timing, and placement of weed control measures are possible, and can

minimize the application of unnecessary or inappropriate herbicide treatments. Project staff members have been working with farmers, consultants, commodity suppliers, and Extension Agents to introduce them to HADSS. Additional information on this system can be found at http://www.hadss.com/.

The weed control situation changed dramatically when Roundup Ready technology was introduced to NC farmers. Growers quickly embraced the Roundup Ready system for cotton and soybeans. In 2002 over 90% of the soybean acreage and upward of 60% of the cotton acreage are planted in Roundup Ready varieties. This compares to the national acreage trend of 71% biotech cotton and 75% biotech soybean (USDA National Agricultural Statistics Service June 2002 report). The speed of adoption surprised both industry and university personnel. Because this new method controlled a wide array of weeds (but not all), many farmers (and professionals advising them) assumed that they could rely on this technology entirely. However, this was not a valid assumption. Many common weeds were tolerant (e.g., morning glories) and were promoted in the system. Other less common weeds became prevalent (e.g., dayflower). Although Roundup Ready provided good control in many situations, NC State University field surveys indicate that almost all weed situations call for a combination of herbicides and that in approximately 15% of the cases Roundup Ready is not the most appropriate choice. (The expectation is that this percentage will increase.) This observation is backed by empirical evidence. A local (Wayne County) herbicide dealer reports that 40% of his soybean customers are now adding another herbicide to Roundup Ready to control tolerant weeds. In a preliminary analysis of cotton fields (all Roundup Ready) monitored by a private agricultural consultant, 26% of the time Roundup Ready was not the most appropriate herbicide choice and 11% of the time another herbicide needed to be added to Roundup Ready for complete control. This phenomenon, called weed shift, is the beginning of returning the herbicide selection process to the pre-Roundup Ready situation.

When farmers quickly achieved confidence in Roundup Ready technology, they began to doubt the value of monitoring weeds and making site-specific decisions. This attitude was backed too often by agricultural consultants, Extension Agents, and NC State University faculty. This situation changed the focus of the HADSS objective. Initially, the focus was for farmers to gain confidence in using a computer-based recommendation system and to develop field-by-field management plans. After Roundup Ready, the focus changed to convincing farmers that one herbicide did not control all weeds (in many cases it did, and HADSS made the appropriate recommendation) and that HADSS could be depended on to give them reliable recommendations. Clearly, this was a more difficult challenge.

HADSS trials were run to increase the user confidence in the tool. Users needed the opportunity to see that HADSS makes good decisions and appropriate recommendations. Results of producer decisions and HADSS decisions were compared. During the season, 39 fields (384 acres) representing corn, cotton, and soybeans were scouted for farmers in Wayne, Lenoir, Craven, and Pitt counties. Recommendations from HADSS were compared with standard producer decisions. The Roundup Ready technology represented 100% of cotton and soybean acreage scouted, whereas conventional varieties represented only 5 fields planted to corn. Producer selection and HADSS recommendations were the same in 72% of these fields. If fields representing corn were removed from these data (a typical situation), similar recommendations occurred in 79% of cases. In 91% (31 of 34 fields) of the fields where Roundup Ready technology was used, HADSS recommended Roundup alone (27 fields) or with a tank-mix chemical (4 fields) as the first recommendation.

One challenge of this project was to provide tools to ensure that increases in are minimized. We continued to promote HADSS through early season educational efforts, specifically weed and herbicide management workshops for agricultural chemical dealers. Forty-five dealers from

Royster Clark and Dixie Fertilizer companies were introduced to HADSS and educated on herbicide resistance, weed shifts, and weed identification. All private agricultural consultants in the Neuse River Basin were trained on the use of HADSS.

When this project was initially developed, herbicide decisionmaking was one of the most difficult tasks of a producer. Much has changed in the last four years due to the aforementioned introduction and rapid widespread adoption of Roundup Ready crops as well as changes in cropping patterns. Over the past few years, there has been a 25% reduction in corn acreage; crop on which many of the soil-applied preemergence herbicides are used. In addition, there has been a 6% increase in the soybean and cotton acreage. These changes in crop production alone have considerably reduced the amount of soil-applied preemergence herbicides used in the Neuse River Basin considerably.

On cotton acreage, where herbicide use has been extensive and where HADSS can be of most use, reduction of herbicide use in project acreage averaged 0.77 lb/acre, a 13% decrease in the volume of herbicides used. The ease of use, acceptable weed control, and commitment through purchase of technology with each bag of Roundup Ready seeds encourages farmers to use Roundup as their primary herbicide. As a consequence, there has been a dramatic decrease in the use of soil-applied preemergence herbicides. Using acreage data on corn and shifts into Roundup Ready varieties, one can conservatively estimate a 40% decrease in the use of soil-applied herbicides. The rapid acceptance and increase in soybean and cotton acreage of Roundup Ready crops has dramatically accelerated the reduction in soil-applied preemergence herbicides. Even though HADSS use has also reduced herbicide use in project acreage, it is important to acknowledge that the use of Roundup Ready technology has been the main factor in the reduction. In fact, to the extent that farmers in the project region adopt Roundup Ready technology, they are less likely to rely on HADSS since their herbicide decisions appear to have been already made.

The dramatic change in herbicide use forced project staff and participants to reevaluate the weed pest management strategy that was a fundamental part of this project. In doing so, several factors indicate that the changes in herbicide use from Roundup Ready technology may not necessarily be permanent. Weed shifts because of reliance on Roundup can easily change the demand for Roundup Ready soybeans or cotton. Additionally, a shift in cropping patterns as a result of commodity price changes could favor corn production, leading to increased use of soil-applied herbicides. Strong evidence already suggests that weed shifts will inevitably occur in Roundup Ready cropping systems, making Roundup either not effective or less effective. In those situations, farmers will again need effective tools for making weed management decisions. In addition, farmers and dealers will always need the ability to identify weed problems and to determine whether it is economically justified to apply an herbicide. Finally, farmers and dealers must be reminded of the need for scouting and its importance in making decisions. Feedback from participants in this project has been invaluable to members of the HADSS development team as they consider both ways to tailor the program to better fit the needs of decision makers and ways to encourage decision making that is based on careful assessment of the situation in each field (G. G. Wilkerson, personal communication).

Demonstration Farms

Demonstration farms have proven to be valuable teaching tools for transferring agricultural information. To this purpose, on-farm demonstrations were established throughout the Neuse River Basin to demonstrate and evaluate effective best management practices for each physiographic region in the basin. The physiographic regions in the Neuse Basin are the Piedmont and the Lower, Middle, and Upper Coastal Plain. The Piedmont is characterized by rolling topography, small agricultural fields, and cattle. Appropriate best management practices are forested riparian buffers, nutrient management and cover crops. The Upper and Middle Coastal Plain topographically

transition from rolling hills to flat areas. This is a highly productive agricultural region where there is a mixture of best management practices, depending on the slope of the land and the degree of ditching. The Lower Coastal Plain is a very flat region that without drainage (ditches) would not be able to sustain agricultural production. The two most useful best management practices in the Lower Costal Plain are nutrient management and controlled drainage. Details on the demonstration farms are provided on the web at http://www.neuse.ncsu.edu/ncmp/demo_farms.html.

Franklin/Wake County Demonstration Farm

On the Piedmont Demonstration Farm in Franklin and Wake counties, the focus was on intensive wheat nitrogen management in the Rocky Branch Watershed. The core demonstration area included six cooperators. Detailed nutrient management plans were developed for each field to account for variability by soil type. Spot checks of wheat yields were made at 15 locations in the project area. The yield checks demonstrated that farmers were overestimating their expected yields, often by almost 50% (Appendix G). In addition, wheat was intensively managed through scouting for cereal leaf beetles and tiller counting, and wheat fertility tests were conducted for two years.

This location is also being used to explore soil sampling strategies that give the best results: whole field, grid, or soil map units. Geographic Information Systems (GIS) technology was used to map soils and wheat yield data to determine whether the Realistic Yield Expectations for the soils typically found in this region matched measure yields. Data have been collected only for one year, and therefore it is too early to state the results. For more information on the project, refer to Appendix H.

Several field days were used to inform agency personnel, farmers, and the news media about project activities, including nutrient management and best management practices. Radio stations and local newspapers publicized information about the project.

In a follow-up to this project, nutrient management with flue-cured tobacco and cotton were demonstrated in a neighboring county. An article in the Southeast Farm Press, which has a circulation of approximately 53,000 in nine different states, highlighted the work with tobacco. Franklin County project details can be found in Appendix G.

Because the field size is small, the topography is rolling, and the streams are highly buffered, sediment rather than nitrogen is of greater concern. Best management practices, consisting of six sediment-reducing practices, were installed and strip-till tobacco was demonstrated (funded by the NC Clean Water Management Trust Fund). The strip-till practice reduced soil loss by 50% or more, depending on the soil type (Appendix G).

Wayne County Demonstration Farms

The focus of the Upper Coastal Plain Demonstration Farms in Wayne County was on nutrient management and controlled drainage for corn, soybeans, cotton, wheat, and tobacco. Intensive soil sampling was completed on over 2,000 acres of cropland on five different farms as a result of the project. Detailed nutrient management plans were implemented for each farm. Cotton petiole nitrate monitoring was used on scores of fields during the project, assuring farmers that their lowered nitrogen fertilizer rates were sufficient.

To meet the challenge of developing thousands of acres of nutrient management plans, project personnel developed two innovative approaches. A simplified computerized nitrogen fertilizer spreadsheet was developed for commercial fertilizer plans. This tool uses significantly less time than the state nutrient management software, although it contains all the components necessary for the plan to be certified under USDA-Natural Resources Conservation Service requirements. In addition, project personnel worked with the agribusiness community to contact farmers regarding nutrient management planning. Agricultural suppliers would invite their customers to a nutrient management planning session. The farmers would be asked to bring field information, such as soil tests, tract numbers, and any orthoquods, to a meeting. At the meeting, project personnel helped the farmers determine their predominant soil type for each field using USDA-Natural Resources Conservation Service Soil Surveys. The Project Technician then took this information and used the nitrogen fertilizer spreadsheet to develop nutrient management plans. The final outcome of the project was that over 69,000 acres of nutrient management plans were developed for farmers in Wayne, Lenoir, Johnston, Greene, and Wilson counties.

Several demonstration tests were conducted as part of the Neuse Crop Management Project. Both corn and cotton nitrogen rate tests were conducted, as well as a foliar potassium test for cotton. Four water control structures were installed to maintain higher water tables and promote denitrification on 400 acres of cropland. A warm season grass buffer was planted on 7,000 feet of ditch bank. In addition, over five miles of ditch banks were maintained with the weed sweep to control large woody vegetation.

Weeds and insects in cotton and soybeans were scouted for the duration of the project. During the first year, HADSS was used experimentally on 450 acres to determine appropriate practices for managing weeds. Water quality monitoring has occurred for the past several years. The Little River has been monitored, as well as two sites at the Center for Environmental Farming Systems in Wayne County, to determine whether there are any changes in stream nitrogen concentrations. This monitoring was funded through the NC Clean Water Management Trust Fund.

Lenoir County Demonstration Farm

On the Middle Coastal Plain Demonstration Farm in Lenoir County, nitrogen application rates were determined using digitized soil maps and their related Realistic Yield Expectations. Yields were measured, and the results demonstrated that the new nutrient management plans had no effect on yields.

To enhance shrub buffers already existing on part of the farm, weed wiping was initiated to control large woody vegetation. Graduate student research projects on this site focused on buffer ecology and width influences on denitrification in shallow groundwater. Over 60 monitoring wells were installed within these shrub buffers to measure nitrogen-reducing values at buffer widths. Redox probes were also installed to ensure that reductions in groundwater nitrate were caused by denitrification instead of by dilution. Vegetative and bird inventories are being collected to determine the habitat quality of these shrub buffers.

Two controlled drainage structures affecting 351 acres were installed at this location. An additional nine structures, draining 1500 acres, were installed on farms throughout Lenoir County.

A kiosk with detailed information was constructed at this demonstration farm, and it has been used extensively as a teaching lab. Two field days were attended by more than 150 people. Nutrient management, buffers, controlled drainage, corn variety trials, and HADSS applications were demonstrated. In addition, the site was used by the NC Department of Agriculture and Consumer Services to educate its Regional Agronomists about the “Neuse Rules” and the best management practices utilized, especially nutrient management. Several agency tours used the location to inform county- and city-level elected officials about the efforts being made by the agricultural community to reduce nitrogen emissions. Lastly, for two years in a row, summer interns from the Center for Environmental Farming Systems visited the site to learn about agricultural best management practices.

Lenoir County

Craven County

Craven County Demonstration Watershed

The Mosley Creek Watershed in Craven County was selected because it is situated in the Lower Coastal Plain and because it represents a natural subwatershed boundary. The fields are heavily ditched to ensure adequate drainage. Eight farmers farm in this subwatershed, and all of them participated in the project.

Field boundaries were georeferenced so that digital soil maps could be used to determine Realistic Yield Expectations. Nutrient management plans were written for all farms in this watershed as well as other fields in nearby watersheds. Some of these plans were written by the original technician. As the result of a problem rehiring a technician to finish the job, Billy McLawhorn, an area crop consultant, wrote the nutrient management plans for this project. He wrote additional plans for a companion watershed – Core Creek – that is also funded by the NC Clean Water Management Trust Fund. The two projects covered the majority of the agricultural area in Craven County.

Twelve nutrient management demonstrations were implemented in Craven County. Corn variety demonstrations were used to help farmers select the highest yielding varieties for local farms. Three tours have been given in this subwatershed. Two of the tours were associated with annual Neuse Conferences held in New Bern, and the other was associated with the Center for Agricultural Partnerships. HADSS was used by four farmers on a total of 184 acres. HADSS locations consisted of 10 cotton fields, 5 soybean fields, and 5 corn fields.

A total of nine controlled drainage structures were installed throughout the watershed. These structures drain a total of 628 acres. Sixteen miles of ditch bank in Core Creek Watershed were weed wiped to establish filter strips. Water samples have been collected monthly from Mosley Creek. The initial water quality monitoring design, which was more ambitious, had to be curtailed because of technical difficulties.

Chapter 4: Management Strategy 2 — Partnerships and Communication

The project staff recognized that partnerships were essential to meet project objectives. The following organizations agreed to participate on the Neuse Crop Management Project advisory board: Corn Growers Association of North Carolina, Cotton Incorporated, Dixie, National Cotton Council, North Carolina Cooperative Extension Service, North Carolina Department of Agriculture and Consumer Services, North Carolina Department of Environment and Natural Resources, NC Farm Bureau Federation, North Carolina Plant Food Association, North Carolina Small Grain Growers Association, North Carolina Soybean Growers Association, Royster Clark Inc., and Southern States Cooperative.

The project staff used extensive outreach to promote best management practices that reduce nitrogen and pesticide losses. Media interest in the project increased as the demonstration sites were developed. Project awareness was promoted through the NeuseLetter (a quarterly newsletter of the Neuse Education Team), local newspapers, radio, television, and project literature. The extensive media campaign provided a multiplier effect for increasing project contacts.

Advisory Board

A 35-person advisory board was established to set objectives and provide input on the work plan for the Neuse Crop Management Project. This board consisted of representatives from commodity organizations, agribusiness, state and federal agencies, NC Farm Bureau Federation, consultants, and farmers. The board was updated and consulted yearly. In addition, the board provided a midterm project review to ensure that the project was meeting its objectives. Members of the initial project advisory board are listed here. Several of these people have moved and were not on the advisory board by the project's end.

Charles Alexander, NC Small Grain Growers Association
Steve Bevington/Tom Jones, NC Clean Water Management Trust Fund
Anne Coan, NC Farm Bureau Federation
Jacob Crandall, USDA-Natural Resources Conservation Service
Roger Crickenberger, NC State University
Paul Dugger, National Cotton Council
Larry Elworth, Center for Agricultural Partnerships
David Hardy, Craven County Cooperative Extension Service
Jim Haskins, AgriBusiness Communications Group
Steve Hodges, NC State University
Richard (Rick) A. Holder, Dixie-Harvey Fertilizer & Gas
Carlton Ipock, Royster Clark
Greg Jennings, NC State University
Gene Kamprath, NC State University
Mike Linker, NC State University
Bill Lord, Franklin County Cooperative Extension Service
Susan Mackey, Center for Agricultural Partnerships
Andy Moye, Producer
Becky McClanahan, National Cotton Council
Billy McLawhorn, McLawhorn Agricultural Consulting Services
Deanna Osmond, NC State University
Jim Parrott, Parrott Farms
Ron Perry, Southern States

Bob Pleasants, Wayne County Cooperative Extension Service
Mike Regans, Greene – County Cooperative Extension Service
Richard Reich, NC Department of Agriculture and Consumer Services
Doug Roberts, Southern States
Howard Singletary, NC Plant/Food Association
Tommy Valco, Cotton Inc.
Jim Wilder, NC Soybean Growers Association
David Williams, Division of Soil and Water
Mitch Woodward, NC Cooperative Extension Service
Joyce Woodhouse, NC Corn Growers Association
Lin Xu, Division of Water Quality, NC Department of Environment and Natural Resources

Web Site

A web site was developed both as an informational site and as a historical record. The Neuse Crop Management Project web site (Appendix J) contains detailed information about the project as well as all four demonstration farms. The site can be accessed at http://www.neuse.Ncsu.edu/ncmp.

NeuseLetter

The Neuse Education Team produces a quarterly newsletter, the NeuseLetter (Appendix E). The newsletter generally has three articles: an article on educational programs, an urban feature, and a column on the Neuse Crop Management Project, which deals with the agricultural sector. Articles have included such topics as nutrient management planning, controlled drainage, highlights from the demonstration farms, and best management practice tours. The newsletter is mailed to over 4000 subscribers in addition to be being posted on the web at http://www.neuse.ncsu.edu. The NeuseLetter mailing list includes many local and state government officials, agribusiness professionals, news media outlets, and concerned citizens.

Field Days

Project staff organized 12 field days to provide opportunities for commodity suppliers, farmers, and agency personnel to view project activities at demonstration sites. These field days also provided additional news coverage of the project.

Popular Press

In the spring of 1999, the project was announced at a press conference in Wayne County that generated coverage on the three major television stations in the Raleigh metropolitan area. Twenty-three articles covering nutrient management and best management practice efforts of the project have been printed in regional multistate farm journals, including the Southeast Farm Press and the Agronomic, Economic, and Environmental Digest, and newsletters. Some of these articles, written by the coordinator, promoted best management practices through local newspapers (Appendix I). Ten of these articles appeared in these local news sources. Southern Farm Press presented several articles on the project. In addition, commodity newsletters were used to explain the agricultural rules and best management practice selection. The project received coverage two different times on television and twice on radio reports.

Presentations

Project information was presented at meetings in North Carolina at the NC Plant Food Association, North Carolina Small Grain and Corn Producers (3 years), Southeast Farm Press Cotton Conference, and the UNC Water Resources Research Institute Conference. On a more of a local level, the project was presented to county commissioners in Wayne County, members of the Wake County Agribusiness Council, participants in the Neuse Council of Governments, members of the

Vanceboro Rotary Club, farmers at three meetings in Craven County, and farmers in the Wayne County Young Farmers organization.

Information on nutrient management or the "Neuse Rules" was presented at numerous meetings. A few are listed: Blacklands Farm Tour (2002), Syngenta Wheat Field Day (2001), NC Small Grains Field Day (2002), and two livestock producer meetings (2001, 2002).

Presentations were also given at both national and international meetings: the 10th Annual Nonpoint Source Monitoring Conference (Osmond et al., 2002a); the American Society of Agronomy in 2001 (http://www.neuse.ncsu.edu/reg_ag_N_basin_scale.html) and 2000 (Osmond et al., 2000c; Zanner et al., 2000); the American Water Resources Association conference (Jennings et al., 2002); the International Conference on Agricultural Effects on Ground and Surface Waters (Osmond et al., 2001a); the 2nd International Nitrogen Conference on Science and Policy (Osmond et al., 2001b); and a conference on buffers that was attended by over 200 people from throughout the United States.

Chapter 5: Management Strategy 3 — Nutrient Management Training

Project staff developed a comprehensive nutrient management training program targeted to farmers and agribusiness professionals. The intent of the training is to increase awareness about how nutrients move into water resources and ways to reduce nutrient losses.

One of the requirements of the "Neuse Rules" was for the NC Cooperative Extension Service to develop and provide nutrient management training for anyone who fertilized 50 acres or more. Alternatively, farmers could have a certified nutrient management plan. To accomplish this training, two Neuse Education Team members prepared the training materials. This was, however, a collaborative effort. First, all interested parties were invited to a "needs-to-know" work group. The training was outlined during this session. Training materials were then developed, after which county agents (the people who actually train the farmers) critiqued the training materials. Changes were made before the training materials were released (Hodges et al., 2000). The materials consist of a training notebook containing the curriculum, slide sets, CDs with PowerPoint presentations, and paper copies of presentation materials (Appendix K). These notebooks were distributed to 35 trainers working for NC Cooperative Extension Service and partnering agencies throughout the river basin. Training topics include the water quality problem, how nutrients move, how best management practices reduce nutrients, nutrient management planning, and eight crop commodity modules.

Training was piloted in five locations in 2000: Person, Orange, Durham, Wayne, and Lenoir counties. Over 100 farmers received certificates of training that year. In 2001 and 2002, nutrient management training was offered throughout the Neuse River Basin to 1,240 farmers and turf managers (Table 5.1).

Table 5.1 Nutrient Management Training Participants by County in 2001-2002

County	Training Participants
Craven	105
Greene	73
Johnston	277
Lenoir	81
Nash/Franklin	69
Orange	45
Pamlico	31
Person	75
Pitt	26
Wake	200
Wayne	135
Wilson	123
Total	1240

Evaluations of the nutrient management training suggests that the farmers find the training useful, particularly the water quality portion.

Early in the Neuse Crop Management Project, project staff held six one-day training sessions, three of which were sponsored by the NC Plant Food Association, for general agribusiness audiences, including crop consultants. The other three sessions were specifically for the three major agricultural product distributors (Southern States, Dixie, and Royster Clark). The intent of this

training was to help agribusiness better understand nutrient management, off-site nitrogen movement, and the impact of best management practices - in other words, to get them ahead of the training we would do later for farmers. Topics for this training included a description of a certified nutrient management plan and who can write the plan, the difference between a nitrogen-only plan and a total plan, a description of NC soil management groups and how they are used to determine nitrogen application rates, and other best management practices used to reduce nitrogen losses.

A state interagency nutrient management computer program is being used for nutrient management planning. Agency personnel that included USDA-Natural Resources Conservation Service, NC Cooperative Extension Service, and NC Division of Soil and Water Conservation were trained to use the nutrient management software. Additional training was held for Neuse Crop Management Project technicians, Neuse technicians (hired by the NC Department of Environment and Natural Resources), USDA-Natural Resources Conservation Service staff and other agency personnel to write certifiable nutrient management plans. In addition, we also held a computer training session with NLEW to give Neuse technicians hired by the NC Department of Environment and Natural Resources hands-on practice with the software. This training allowed Neuse technicians to track BMP implementation (including nutrient management) and account for nitrogen losses associated with these best management practices. It would have been impossible to present the basinwide nitrogen reduction information in Chapter 3 without the development of this tool.

Chapter 6: Management Strategy 4 — Evaluation

Evaluations were conducted during the Neuse Crop Management Project to establish baselines, to collect basic data, to ensure that the project was focused and on target, and to assess project results.

Focus Group Session

A focus group session of agribusiness and dealer representatives took place in Goldsboro in February 2001. The intent of the focus groups was to help direct basinwide education programs. A better knowledge of how farmers make decisions related to products and services offered by agricultural industries could help project scientists tailor training and education programs to meet those needs. Also of interest was information concerning how the companies have been changing or organizing themselves to meet consumer demand. The focus group found that more farmers are relying on agribusinesses to provide services in addition to products and that farmers depend on people they trust for advice regarding which products to buy. A detailed report of the focus group session is in Appendix L.

Fertilizer and Cropping Survey

A survey to determine fertilizer practices and best management practice implementation was conducted in 1999 with funding from pass-through US Environmental Protection Agency 319 funds. Information on base crops, acreages, nutrients applied, and best management practices was collected and analyzed for approximately 6,000 individual crop fields. These data were passed on to the county level groups to be used in their NLEW calculations.

Fertilizer Application Rate Survey

Early in the project, and in association with another grant, 30 farmers in the basin were surveyed regarding their nitrogen fertilizer rates with weighted averages calculated: corn (158 lb N/acre), cotton (88 lb N/acre), pasture/hay (194 lb N/acre), tobacco (83 lb N/acre), and wheat (122 lb N/acre). These application rates were similar to the rates our cooperating farmers were using and provided another way to check on rates.

Cost-Benefit Analyses

Cost-benefit analyses provide important direction in determining the financial feasibility of that which is being analyzed. Few projects have ever provided cost-benefit analyses of agricultural best management practices. Two cost-benefit analyses were conducted during the life of this project: one analysis was for the best management practices, such as controlled drainage, cover crops and buffers, and the other was for nutrient management.

The nutrient management cost-benefit analysis was produced using information from our cooperators. The cost-benefit ratio for nutrient management was highly variable, depending on soil test levels and farmers' practices, but in general, it appears that many farmers can save $20-40 per acre by using nutrient management. Detailed analysis was conducted on five farms in the Piedmont and an equal number of farms in the Coastal Plain. The Piedmont information can be found in Appendix E.

The cost-benefit analysis for the other best management practices used in this project was unique. The benefit of the best management practices was highly dependent on the specific best management practice and the physiographic region. For instance, wooded riparian buffers were found to be more cost effective in the Piedmont than in other regions, whereas controlled drainage was only cost effective in the Lower Coastal Plain.

Seven different articles present the cost-benefit information: four fact sheets, two documents, and a journal article (Wossink and Osmond, 2002). The fact sheets and documents can be found at http://www.neuse.ncsu.edu/aginfo.html.

Water Quality Monitoring

Detailed water quality monitoring, funded through the NC Clean Water Management Trust Fund and UNC Water Resources Research Institute took place at one of the farms (Lenoir County) on a shrub buffer system. Preliminary data indicates that nitrogen reductions by these buffer systems range from 60% to 95%, thus validating the usefulness of these buffer systems. Farmers would find shrub buffers much more acceptable than tree buffers, so this is an important finding. Final results will be available in June 2003. The project focused on producing results at the field level. Evaluation of the project's efforts was based on how well the practices have been made available and on the economic and environmental impacts on the region's farmers and their farms. Detailed descriptions of monitoring data and research reports are provided in Appendix M.

Project Evaluations

Project evaluations were conducted at midterm and at the end of the project to identify specific project successes and weaknesses.

Midterm Evaluation

The midterm evaluation was conducted by members of the advisory board. They visited project personnel and toured all four demonstration farms. They identified few problems and encouraged project staff to continue the work. The following are just a few comments from the midterm evaluation. Details of the evaluation are in Appendix C.

- Nutrient management implementation was successful where farmers received local technical assistance on data analysis and plan development.
- The HADSS program worked well for determining which herbicides to use, but where Roundup Ready soybeans and cotton were grown, the program was considered too data intensive.
- Nutrient management training targeted to agribusinesses, including fertilizer salespeople and consultants, successfully increased the local implementation of best management practices.
- The project was meeting its objectives and should continue for the remainder of the term.

Final Evaluation

Project conclusions from the final evaluation are summarized here. The purpose of the report was to provide a “sociological snapshot” of the project by giving the diverse stakeholders the opportunity to voice their opinions about the project’s implementation and impact. For the full evaluation that includes lessons learned and recommendations, see Appendix D.

Thirty-two stakeholders were interviewed: 12 growers and 20 nongrowers. A random sample of three growers in each county was chosen for the interviews, plus one key grower who had worked intensively with the project. The 20 nongrowers represented six different sectors: the funding agency, the project principals, the technical (field) staff, agency contacts, agribusiness contacts, and NC State University faculty. In-person interviews were conducted to generate the information that follows.

Both the growers’ and the nongrowers’ assessments of the Neuse Crop Management Project and its impact were positive. The project reportedly met and exceeded its objectives, and its strengths outweighed its deficits. Its multisector, multidisciplinary approach was reported to be effective and the project staff consistently were rated as highly competent by both growers and nongrowers.

There was good collaboration among the diverse stakeholders, which generated useful information, increased the agencies' knowledge of each other's technical capacities, and strengthened the links between agencies. The three problems consistently identified by the nongrowers were the inherent problem of staff turnover in a short-term project, the need for better communication among project staff, and the lack of progress in the weed management component that was mainly due to the growers' widespread use of Roundup Ready seed.

It is important to note that, when the "Neuse Rules" were written, the general feeling among growers was that they had been unjustly accused of using excessive nitrogen and thus of being major contributors to pollution in the Neuse River. Their view was that the accusation was "all politics," designed to make farmers the culprits, and that urban sprawl was as much or more responsible for nitrogen loading in the Neuse River. As virtually every grower pointed out, the fact that they had to control production costs meant that they could not afford to "throw around nitrogen." At the beginning of the project, the basic position among growers was that their fertilization rates were appropriate, based on their long-term experience with the land they farmed and on technical assistance from suppliers, the NC Department of Agriculture and Consumer Services, and the NC Cooperative Extension Service.

Another important factor to recognize is that growers currently face difficult economic circumstances. According to growers, part of controlling production costs was using only as much nitrogen as they needed. From the nongrowers' perspective, the current agricultural economy was likely to have a conservative influence on their behavior and the perceived risks of a change such as implementing different nutrient management practices, even if the change potentially decreased costs and maintained yields. Given this context, the project did a good job of increasing growers' awareness and use of the options to improve their nutrient management.

Interviews with growers led to the conclusion that "appropriate" nitrogen rates are subjective. Growers reported that their decisions for applying nitrogen were based on their experience with the land, soil samples, rainfall, and technical recommendations from NC State University, suppliers, and NC Cooperative Extension Service. All the growers said that they adapted recommendations from the latter three sources based on their experience. Also, several reported that the state's Realistic Yield Expectations were too low and that they could exceed them, which influenced their fertilization rates. This fact affected their view of their nutrient management plans, in which the Realistic Yield Expectations were an important factor. At least one grower also reported that his Wagram soils were different than elsewhere so his input rates were idiosyncratic also. The growers' general feeling was that "you can't fertilize by the book, you have to fertilize by the field" and that "sometimes someone who's in the field every day knows better than the guys who come from Raleigh."

The big growers who worked intensively with the project and had significant acreage under nutrient management plans had more confidence in their plans. This may have been the result of more contact with the project or of their greater interest in better management, but even a big grower stated that he didn't follow his nutrient management plans "like the Bible." The interviews showed that growers understand the need for good economic and environmental performance. But at this point each grower is using his or her plan "in accordance with my experience of what's worked well for me in the past."

Chapter 7: Conclusions

The agricultural community in the Neuse River Basin in North Carolina faces intense pressure to comply with environmental regulations while experiencing difficult economic conditions. The Neuse Education Team has been successful in helping farmers meet their obligations by improving their understanding of best management practices and promoting economically sound farm management through the Neuse Crop Management Project. Project conclusions are listed here.

1. The project exceeded its numerical objectives:
   - Over 100,000 acres under nutrient management plans
   - 40% reduction in preemergent herbicides
   - 23% reduction in nitrogen applied per acre of cropland

2. The project's success, as determined by the final evaluation (see Appendix D), was based on a unique set of circumstances: the existence of the Neuse Education Team and the many other agencies and organizations working in the Neuse River Basin; the extensive consultation and feasibility study at the beginning of the project, which led to the creation of strong working relationships that made the project successful on a very significant scale; the ability to obtain funding from multiple sources; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project structure; the willingness of the farmers to be part of the solution; and the regulatory pressures for nitrogen reduction.

3. The project's major strengths were the preproject investment of time to build a solid foundation for multisector, multidisciplinary work; collaboration among diverse stakeholders; excellent staff; project technicians that allowed intensive, one-on-one work with growers; and an egalitarian structure that allowed staff to make decisions and do their work relatively independently.

4. The project was extremely cost effective. In 2002, nutrient management plans were written for over 105,000 acres. The commercial rate for nutrient management planning is $8.00/acre. Had the commercial rate been charged, the project would have spent the majority of the funding received from the Center for Agricultural Partnerships on only nutrient management planning. As a result of the cost effectiveness of the project, many other educational and promotional activities occurred, including the HADSS work.

5. The project met critically important needs that were not sufficiently funded through the state budget:
   - Training materials for the mandated nutrient management education program
   - Computerization of the best management practice accounting and tracking tool – NLEW
   - Computerization of the new tool – PLAT – needed to meet new USDA-Natural Resources Conservation Service nutrient management standards
   - Development of the commercial fertilizer computerized spreadsheet used in developing nitrogen fertilizer plans

6. Interagency cooperation was facilitated by funding for the intensive local demonstration projects located throughout the river basin.

7. Nitrogen management is an effective and cost-efficient means for controlling nonpoint source nitrogen from agricultural sources. Before the project, many producers used their soil tests for lime but not phosphorus, and they applied nitrogen at standard nitrogen rates. Two-thirds of the

growers reported that they decreased their nitrogen application rates as a result of project recommendations. Most already had decreased their nitrogen rates on tobacco to some extent, to produce the lower-nitrate crop currently in demand. Some growers felt that the project did not significantly change their nitrogen rates because they were not overapplying it. Some examples of estimated rate reductions due to the project are 15 to 20% on cotton, 14 to 28% on corn, 15 to 24% on tobacco, and 4 to 20% on wheat. One farmer stated, "The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work."

8. Growers appreciated the project's extensive soil sampling because it improved their knowledge of an important production factor and was a key factor in designing their nutrient management plans. The size of the project's sampling blocks - two- or five-acres - provided better information to the growers than the ten-acre blocks they generally sampled. The soil sampling gave growers a better basis for determining nutrient application rates, including lime.

9. More focused, intensive work with growers is necessary to get a significant amount of their acreage under nutrient management plans.

10. The "big" growers who worked intensively with the project were more positive about their nutrient management plans. According to a consultant who worked with the project, this is because growers who have more contact with the project and more acreage under nutrient management plans see the benefits of improved nutrient management more clearly.

11. Almost no information exists on the costs and benefits of controlling nonpoint source nitrogen from agricultural sources. A cost-benefit analysis of the best management practices used to control nitrogen, excluding nutrient management, demonstrated that some practices were not cost effective (cover crops), whereas other practices, such as buffers (in certain areas) were highly cost effective. A separate cost-benefit analysis of only nutrient management showed that farmers can typically save up to $50 per acre by using realistic yield expectations to determine fertilizer nitrogen applications (Appendix E).

12. The major incentives to growers for using their nutrient management plans were to improve water quality and to control production costs. In the words of one grower, "[nutrient management plans are] good for the river and for my pocketbook." They also pointed out that they live where they work and drink the groundwater, so they have a vested interest in controlling pollution.

13. Field demonstrations showed that nitrogen management recommendations currently provided by the NC Department of Agriculture and Consumer Services are usually sufficient to meet crop yields.

14. The project should have been designed to have only one focus – in this case, reducing nitrogen because of the legislation that affects this pollutant in the Neuse River Basin.

15. The weed management component did not meet participants' expectations. This was partly because the widespread use of Roundup Ready seed made Roundup the growers' chemical of choice, and partly because growers would not invest time in the extensive scouting that the Herbicide Application Decision Support System (HADSS) required. One important outcome of the HADSS component of the project, however, has been participant feedback. The feedback has been invaluable to members of the HADSS development team as they consider ways to

tailor the program to better fit the needs of decision makers and ways to encourage decision making that is based on careful assessment of the situation in each field.

16. Five years would be a more appropriate time frame for increasing the growers' awareness and use of the options to improve nutrient management and would facilitate retaining staff.

Chapter 8: References

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