GUIDELINES FOR CALCULATING

NITROGEN LOAD REDUCTION CREDITS

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March 7, 1997

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1. INTRODUCTION

The Tampa Bay National Estuary Program (TBNEP) is currently conducting a series of workshops to help achieve a central objective of the program: to restore seagrasses in the bay to their 1950s extent. To achieve this objective, management actions are being developed to manage nitrogen loading to Tampa Bay. The guiding paradigm for managing nitrogen in Tampa Bay is the relationship between nitrogen loading, chlorophyll *a*, light attenuation, and seagrass growth. Janicki and Wade (1996) estimated limits on nitrogen loading that will keep chlorophyll *a* in the bay waters at concentrations low enough to allow sufficient light penetration to meet seagrass restoration targets (e.g., to allow seagrass to recolonization to their 1950s extent within the bay).

Work by Janicki and Wade (1996) has suggested that current levels of nitrogen loading are appropriate to meet seagrass restoration targets. However, projected future loadings may rise to levels that would exceed the maximum loadings recommended for seagrass recovery (Zarbock et al., 1996b). Therefore, current loadings must be reduced at approximately the same rate as the projected increases in future loadings to preclude future increases in nitrogen loads to the bay.

The workshops bring together participants of the TBNEP Management Conference and the community to discuss how to implement the "Nitrogen Management Strategy", to minimize increases in nitrogen loading given projected future development in the region. The Nitrogen Management Strategy includes components to monitor and assess those action plans now in the CCMP, and to agree to "credits" for nitrogen load management activities that will reduce loads at a rate sufficient to offset projected future increases. **One of the major challenges for workshop participants is to develop a means of estimating nitrogen load reductions which result from a variety of different types of projects and activities.**

Many of the action plans that comprise the TBNEP Comprehensive Conservation and Management Plan (CCMP) address nitrogen load management either directly or indirectly. The nitrogen load reduction that would result from implementing some action plans can be estimated with some certainty. Examples include the construction of stormwater best management practices (BMP) or upgrading wastewater treatment systems. Potential nitrogen load reductions resulting from implementing some other action plans, however, are not so easily estimated. Management activities such as public outreach programs, permit compliance monitoring, or education programs cannot readily be evaluated in terms of pounds of nitrogen removed.

Proposed methods of calculating nitrogen credits based on implementing a variety of management practices have been developed, and have been reviewed by the TBNEP Technical Advisory Committee (TAC) Modeling Subcommittee. **This document presents methods for calculating nitrogen load reduction credits, as recommended by the Modeling Subcommittee.**

2. METHODS FOR CALCULATING NITROGEN LOAD REDUCTION CREDITS

The purpose of this document is to provide guidelines for calculating credits for nitrogen load management, or load reduction, for action plans that are currently in the TBNEP CCMP. Methods by which nitrogen load management or reduction credits are estimated address a major objective of the TBNEP: to meet the following goal for water and sediment quality. The nitrogen load management goal, as stated in the CCMP, is:

Maintain or slightly reduce existing nitrogen loadings to Tampa Bay.

There are several action plans within the CCMP that address this goal. All of these action plans for reducing nitrogen loading can be classified in one of three categories:

- **Structural** - Action plans that call for the construction of a physical facility for reducing nitrogen loading are classified as having a structural approach. This category includes stormwater BMP projects, capital improvement projects, wastewater treatment and effluent management, and increased treatment of emissions from power plants or industrial point sources.

- **Education and Implementation** - These are community participatory/ nonstructural action plans with an indeterminate level of voluntary participation, including Florida Yards & Neighborhoods, Operation Bayworks, agricultural conservation plans, etc.

- **Regulatory/Enforcement** - Action plans that recommend increased compliance with existing environmental regulations through additional enforcement, or by enacting new regulations fall within this category.

The TBNEP TAC Modeling Subcommittee completed a review of the available methods for calculating nitrogen load reductions for these classes of action plans at a meeting on March 4, 1997. The Modeling Subcommittee recommended at that meeting that nitrogen load reduction credits be calculated only for structural action plans, for action plans that implement Florida Yards and Neighborhoods, and for other action plans that have acceptable methods of calculating load reductions. Methods for calculating nitrogen load reductions for each of the above action plan categories are detailed in the following sections.

It should be recognized that the credit development process must be flexible, and will be re-examined in the future to assess the effectiveness of action plan implementation. At that time, the credit calculation methodology and criteria may be revised. However, based on the TAC Modeling Subcommittee review, the appropriateness of awarding credit for nitrogen management is recommended to be based on a single criterion:

- **How many pounds of total nitrogen (TN) will be removed from the load to the bay if an action plan is implemented?**

  Answering this question will allow the most credit to be given to those action plans that have the most success in managing nitrogen loads to the bay. Thus, the common currency for evaluating these action plans is pounds of TN.

As additional data become available and the methodology is refined, additional criteria may be included for the nitrogen load reduction calculations. Criteria that may potentially be used in the nitrogen load reduction process in the future include :

- **How effective/accurate is the method used to estimate the number of pounds of TN removed from the load to the bay resulting from implementing this action plan?**

  The confidence that we can place in the estimates of TN load removal may be considered in the future when giving credit for actions taken.

- **Where will the reduction take place?**

  Nitrogen loads delivered to upper Tampa Bay (Hillsborough Bay and Old Tampa Bay) have more impact on the entire bay, on a pound-by-pound basis, than nitrogen loads delivered to the lower portions of the bay. This is because nitrogen inputs to the upper bay segments will also affect the middle and lower segments due to intersegment circulation and flushing. Thus, an action plan that addresses nitrogen loading in Hillsborough Bay or Old Tampa Bay could receive more credit than an action plan that reduces TN in Lower Tampa Bay. Under this scenario, local governments would be able to undertake, or participate in, action plans outside their own jurisdiction.

- **Is there monitoring or other documentation of the effectiveness of the action plan?**

  Being able to gage the success of action plans is extremely critical for refining management approaches and re-assessing the credit calculation process. Thus, action plans that include provisions for monitoring the effects of the activities could receive additional credit, when a methodology of evaluating the appropriate level of credit is determined.

The guidelines for calculating nitrogen load reductions are discussed below for each category: structural, education and implementation, and regulation and enforcement. For each category, available data, methods for calculating load reductions, and an example are given.

2.1) Structural

Structural methods of nitrogen load reduction include the use of physical facilities and processes. Two major means of load reductions available to local governments are implementing stormwater treatment BMPs, and enhancing wastewater treatment and wastewater effluent management from domestic and industrial point sources through reuse. Advanced treatment of emissions from industrial facilities (e.g. power plants) is another activity that can result in significant nitrogen load reductions. These three categories of structural means of nitrogen load reductions are discussed below.

2.1.1) Methods for Calculating Nitrogen Load Reduction for Stormwater BMPs

Available data and information

- Existing site-specific studies

Pollutant load reductions are frequently a major consideration in the design and construction of stormwater systems. The potential benefits of many stormwater BMP projects have been documented in feasibility reports that are developed to assist in design specifications for these facilities. Credits for nitrogen load reductions may be estimated based on the findings of existing reports, subject to a review of the underlying assumptions and methods used to estimate the effectiveness of the BMP as documented in the report.

- Literature values for BMP treatment efficiencies

Substantial literature is available documenting hydrologic and water quality characteristics of various land uses (Appendices B and C, from Zarbock et al., 1996a), and ranges of treatment efficiencies of common stormwater BMPs (Wade et al., 1997). Data obtained from field monitoring of inflow and outflow water quality of BMPs allow estimates to be made of the pollutant load attenuation capabilities of stormwater ponds, created wetlands, swales, infiltration systems, etc. Summaries of these data are available for stormwater management systems, and may be used to estimate nitrogen load reductions from similar facilities. Ranges of treatment efficiencies for several stormwater BMPs are presented in Appendix D. Data for Appendix D were obtained from a variety of sources, as described by Wade et al. (1997).

- Optimization Model

TBNEP has developed an automated protocol for determining the optimal selection of stormwater BMPs for a given situation (Wade et al., 1997). The selection of BMPs may be based on a variety of criteria, including effectiveness, cost, land availability, etc. The Optimization Model may be used to estimate feasible nitrogen load reductions resulting from BMP use. The Optimization Model construction and application is described fully by Wade et al. (1997).

Methodology

- Use project-specific estimates of nitrogen load reduction to determine credits.

Using previously developed project-specific estimates of nitrogen load reductions to estimate credits will be contingent on a review of the documentation used to make those estimates. Underlying assumptions, design specifications, assumed treatment efficiencies, extent of treated area, and other pertinent data will be examined to assure that the results of the study can be justified.

- Use literature values of BMP treatment efficiencies to determine credits.

This method of calculating nitrogen load reduction includes determining the extent and land uses of the area to be treated, estimating nitrogen inputs to the subject BMP facility by calculating runoff volumes and loads using literature values of runoff coefficients, land use-specific runoff quality, and treatment efficiency (Zarbock et al., 1996a). The pollutant load potentially removed by the BMP is estimated by multiplying the inflow load by the treatment efficiency.

- Use Optimization Model to determine nitrogen load reduction credits.

The TBNEP Optimization Model may be used to estimate nitrogen load reductions. For this procedure, design criteria of a proposed BMP would be entered into the model and the model would estimate a potential load reduction based on the input parameters. The model default input parameter values (Appendix D) may be used, or other appropriate values may be input to the model.

Examples

- Existing site-specific studies

One local government project that has been investigated for nitrogen load reduction potential is Hillsborough County's Delaney Creek Wetland Restoration

Project. *Because this project was conceived several years ago and therefore may not be eligible for nitrogen load reduction credits through TBNEP, the following discussion should be viewed as an example of the methodology only.* This project includes the expansion of an existing wetland to enhance treatment of surface water from the 16-square mile Delaney Creek watershed. It has been estimated by the County that, based on an estimated TN removal efficiency of 25% for the wetland system, this project will result in a nitrogen load reduction of 0.7 tons of total nitrogen (TN) per year, in terms of load delivered to the bay by the creek.

Prior to calculating credits for this activity, the assumptions used to develop the load reduction would be checked. Information on watershed area and land use, wetland system design and specifications, estimated current nitrogen loadings from the creek, and other relevant data will be evaluated for accuracy and appropriateness. Using this example, if the assumptions and methods used to calculate the potential load reductions are found to be accurate and reasonable, then the 0.7 tons/year would be credited to Hillsborough County.

- Literature values

The following is a hypothetical example of using literature values for treatment efficiencies to determine credit for nitrogen load reduction. Assume that a drainage area of 100 acres of medium density residential land use currently has no stormwater treatment facilities. Stormwater treatment for this 100-acre area is to be provided by the construction of a pond. It is assumed that the pond will provide treatment to the level required for SWFWMD Management and Storage of Surface Waters (MSSW) permitting. The potential nitrogen load reduction resulting from the pond may be estimated as follows:

- Using available literature as summarized in Appendix B, medium density residential land on soil with a hydrologic group rating of "C" has an average annual runoff coefficient of 0.40, meaning that over a year, on the average 40% of rainfall falling on that land will become stormwater runoff. Given a hypothetical long-term rainfall of 55 inches per year, 22 inches of that rainfall will leave the site as runoff. If it is assumed that 90% of the annual rainfall (approximately 20 inches) is subject to treatment, based on MSSW rules, then the 100-acre area could generate approximately

$$(100 \text{ acres} \times 43{,}560 \text{ ft}^2/\text{acre}) \times (20 \text{ inches} \times 1\text{ft}/12 \text{ inches}) \times 7.48 \text{ gallons/ft}^3$$
$$=$$
$$54.3 \text{ million gallons of runoff/year}$$

- The TN concentration of the medium density residential runoff is estimated to be 2.04 mg/L, based on a synthesis of literature values shown in Appendix C. The untreated TN load generated by the area is then:

(54.3 million gallons x 2.04 mg/L x 8.342 conversion factor)
=
924 pounds TN/year

- The nitrogen load reduction caused by the pond can be estimated using literature values for pond treatment efficiency. A typical TN treatment efficiency for wet ponds (Appendix D) is 30%, which means that 0.30 of a TN load entering the pond will be attenuated and 0.70 of the input load will pass through the pond. Thus, the nitrogen load reduction credit for the pond would be:

(924 pounds TN/year x 0.30)
=
277 pounds TN/year

- Optimization Model

Using this method, design criteria and specifications of a proposed facility will be entered into the model, which will determine the resultant load reduction based on default of input parameter values. The Optimization Model uses much the same methodology as described above for literature values, but can be used for broader or more complex applications. The use of the Optimization Model is described by Wade et al. (1997).

2.1.2) Methods for Calculating Nitrogen Load Reduction for Wastewater Treatment and Effluent Management

Available data and information

- Existing site-specific studies

Enhancements to wastewater treatment processes or effluent management techniques are usually preceded by feasibility studies and other evaluations required for permitting. Water Quality-Based Effluent Limitation (WQBEL) studies often provide information that can be used directly for the purpose of evaluating load reductions.

Several local governments have generated reports estimating nitrogen load reduction resulting from changing effluent discharge methods. Direct discharge of effluent to the bay, more common in the past, produces a certain load based on rates of flow and effluent concentration. If the effluent is re-directed to spray irrigation and reuse, the TN load that reaches the bay may be substantially reduced. Evaluation of the assumptions and methods used to estimate load reductions would precede use of existing reports to determine nitrogen load reduction credits.

- Permit data and literature values

Existing loads from wastewater treatment facilities must be determined prior to estimating load reductions. The Florida Department of Environmental Protection (FDEP) mandates that each wastewater treatment plant (WWTP) produce monthly operating reports (MOR) of effluent flow rates and quality. Effluent flow rates and concentration data may be used to estimate total load from the plant.

The treatment efficiencies of WWTP are mandated by law, and can be tightly controlled. Thus, nitrogen removal rates for individual processes can be estimated relatively accurately and the ensuing load reduction calculated with some certainty.

Methodology

- Use previously generated load reduction estimates (subject to checking).

As with stormwater facilities, previously-generated estimates of load reductions resulting from wastewater treatment operations would be checked to assure that the assumptions and methods used were accurate and appropriate. Current and projected flows, treatment efficiencies, and load attenuation methods would all be subject to evaluation. Upon verification of the soundness of the estimates, data produced in the study would be used to determine credits.

- Permit data and literature values

Permit data can be readily obtained from the FDEP. Monthly average flows and nitrogen concentrations are generally available from these records, enabling estimates of current conditions to be made. WWTP processes can provide desired treatment levels based on operating criteria, so the proposed level of treatment can be established with some certainty. In addition, literature values exist to estimate nitrogen load attenuation through land application of effluent. Thus, projected future loads resulting from treatment upgrades or changes to effluent discharge may be subtracted from existing loads to yield load reductions.

Example

For a hypothetical example, assume that a local WWTP discharges advanced wastewater treatment (AWT) effluent directly into Tampa Bay. Based on an existing study, or on MOR records, it is estimated that the discharge averages 1 million gallons per day (mgd), and that the TN concentration averages 3.0 mg/L. Thus TN loading under existing conditions is:

(1 mgd x 3.0 mg/L x 365 days/year x 8.342 conversion factor)
=
9,134 pounds TN per year

To reuse the effluent for landscape irrigation, it is proposed to convert the surface water discharge to land application by spraying. TBNEP has published information supporting an assumption of 90% reduction in TN loads from most wastewater if it is applied to the land surface (Zarbock et al., 1994). The City of St. Petersburg's TN reduction in reuse water has been estimated to be 95% because of treatment processes that maximize the amount of ammonia in the effluent. This assumption is the result of an investigation by TBNEP, the City of St. Petersburg, and others into the average overall rate of attenuation of nutrients in wastewater effluent that is used for spray irrigation (Zarbock et al, 1992). Therefore, the nitrogen load to the bay resulting from changing the effluent discharge to spray irrigation (based on the 90% reduction) is:

(1 mgd x 3.0 mg/L x 8.342 x 0.1)
=
913.4 pounds TN/year

The resultant load reduction and associated credit is (9,134 - 913.4 lb/year) 8,221 pounds TN per year.

2.1.3) Methods for Calculating Nitrogen Load Reduction for Power Plant Emission Controls

Available data and information

Emissions to the atmosphere from power plants are highly regulated. Detailed reporting of pollutant discharges, including nitrogen (NO_x) are required by FDEP. These data are available to estimate existing levels of discharges from power generating facilities.

However, although permit data provides estimate on discharges from power plants, these data do not address the deposition of the pollutants. Determining the fate of atmospheric pollutants is the subject of much research, but few data are available to help determine what percent of NO_x emitted from a local power plant falls on Tampa Bay and what percent is carried out of the watershed prior to its deposition. Research by the Chesapeake Bay Program suggests that the ratio of total power plant emissions to local TN deposition is in the range of 100:1. This means that for every 100 pounds of all material discharged from local facilities, one pound of nitrogen is delivered to the bay. A Florida Administrative Hearing Officer recently allowed a ratio of emissions to local deposition of 400:1.

Methodology

Calculating credits for nitrogen load reduction for power plants will involve estimating or verifying estimates of emissions under current conditions, and estimating reductions in emissions resulting from upgrades to treatment. The emission reductions would be estimated by subtracting current emissions from projected future emissions. Reductions in nitrogen loads would then be estimated by multiplying the emission reduction by 0.01 (1%).

Example

As a hypothetical example, assume a local power plant has a reported average NO_x emission of 50,000 tons per year, based on FDEP files. Adding additional scrubbers to the facility is projected to decrease NO_x emissions to 30,000 tons/year. Thus, the emission reduction can be estimated to be (50,000 - 30,000) 20,000 tons per year. The resultant nitrogen load reduction to Tampa Bay would then be estimated by multiplying the emission reduction of 20,000 tons per year by 0.01 to yield 200 tons per year. Credits may be calculated for funding or otherwise supporting activities that result in reduced atmospheric emissions.

2.2) Education and Implementation

Education and implementation activities for nitrogen load reduction include numerous public outreach efforts. A variety of education and implementation activities are currently being implemented or planned by local governments under the **Florida Yards and Neighborhoods (FY&N)** program. This umbrella program provides opportunities for public involvement and education for several issues such as promoting environmentally-sound landscaping through reduction of fertilizer application, integrated pest management, xeriscape, and water conservation. Public information and education is also provided through interpretive signage at environmental sites throughout the watershed.

Other public outreach programs have been implemented or proposed by local governments. Although these activities intuitively provide environmental benefits to the bay through public education and action, no acceptable methods of quantifying the benefits in terms of nitrogen load reduction have been shown for many worthy programs. Receiving credits for reducing the nitrogen load to the bay for the following programs will be contingent on a demonstration of their effectiveness. Some of these programs include:

- Adopt-a-Pond - This program is sponsored by Hillsborough County, and gives residents the opportunity to enhance lake water quality and habitat through voluntary maintenance and habitat creation. Over 400 residents have participated in wetland planting projects through this program, and almost 300 have attended informational seminars.

- Operation Bayworks - Also sponsored by Hillsborough County, Operation Bayworks encourages businesses and agricultural operations to utilize environmentally-sound practices such as integrated pest management, xeriscape, and water conservation.

- Hillsborough County Lake Monitoring Program (Lakewatch) - This program will work in conjunction with the University of Florida's "Florida Lakewatch" program to enlist residents to monitor water quality in Hillsborough County lakes.

- Training inspectors to identify and require erosion and sediment control at construction sites - This type of program would instruct local government building inspectors to recognize the need for erosion and sediment control at construction sites, and to work with construction site supervisors to ensure that sound site construction practices are used.

2.2.1) Methods for Calculating Nitrogen Load Reductions for FY&N Education and Implementation Programs

Available data and information

Although FY&N public outreach activities intuitively provide benefits to the local environment, little information is available on how to measure the level of effect that these activities have. Public education and information programs may result in reduced nitrogen loading through reduction in fertilizer use, for example, but estimating a load reduction resulting from these activities cannot be made with a great deal of certainty.

However, information is available on topics such as turf grass nutrient uptake rates and typical fertilizer application rates, as are surveys that estimate what percentage of homeowners in an area fertilize their lawns, and how frequently they do so.

Methodology

The methods used to calculate nitrogen load reduction credits for participation in FY&N uses the following steps:

- The following information regarding typical turf grasses was obtained from IFAS, University of Florida:

  - typical recommended application rate of nitrogen (N) for St. Augustine and Bermuda grass is approximately 86 lb/acre/year (1 lb/1,000 ft^2 twice annually).

  - in one experiment, the dry weight of clippings of Bermuda grass averaged approximately 100 lb/acre/month for nine months on several test plots, for typical landscaping practices.

  - nitrogen (N) makes up 2-6% of the dry weight of Bermuda grass.

- If it is assumed that N makes up 4% of the dry weight of turf grass, then regular mowing yields approximately 4 lb N/acre/month (100 lb/acre/month x 0.04), or 48 lb N/acre/year in grass clippings.

- If the grass clippings are allowed to remain on the lawn, up to 48 lb N/acre/year could be available for lawn fertilization from this source.

- Thus, the typical (fertilizer-based) nitrogen application rate can be reduced to account for the clippings as a source of nitrogen. Because all the grass clippings may not be available for use as fertilizer because of washoff, etc., it is recommended that a 10% reduction in nitrogen application be credited for not removing grass clippings, which is used as a surrogate for participation in FY&N programs.

- The TBNEP CCMP presents land use-specific nitrogen loading rates for Tampa Bay Watershed land uses. On a watershed-wide basis, residential land use yields an estimated 4.52 lb N/acre/year (Appendix A).

- A 10% nitrogen load reduction credit can be applied to the 4.52 lb N/acre/year load from residential land uses for lawns in neighborhoods or businesses participating in FY&N. This will account for reductions in fertilizer application and other environmentally-beneficial practices resulting from increased public awareness.

- Thus, a nitrogen load reduction credit of 0.45 lb N/year for each acre of lawn in all participating neighborhoods or businesses can be calculated on the basis of sponsoring FY&N programs.

Example

Assume a 100-acre neighborhood of medium density residential land use participates in the FY&N program, which is sponsored by the local government. Of the 100 acres, approximately half (50 acres) is lawn. Using the above assumptions, the credit for a nitrogen load reduction of 22.5 lb/year (50 acres x 0.45 lb N/acre/ year) would be estimated for that neighborhood.

2.3) Regulatory and Enforcement Programs

Regulatory and enforcement management actions are two very important means of controlling nitrogen loading to Tampa Bay. However, these activities are very difficult to quantify in terms of the level of benefit derived from their implementation.

One action that may be used to achieve nitrogen load reductions is to enact new regulations or make existing regulations more stringent (stormwater management requirements, for example). The nitrogen load reduction realized from such actions will be specific based on the requirements of each individual regulation, and will be evaluated on a case-by-case basis.

Increased compliance and enforcement monitoring is another type of management action that can lead to nitrogen load reductions. However, no credits will be given for activities that are already being undertaken by local governments. If a local government initiates a new compliance and enforcement monitoring program, or enhances an existing program, then credit will be given. The amount of credit given will be contingent on the scale and success of the new or enhanced program.

Example 1

Manatee County requires that all development in the watersheds of potable water reservoirs (Manatee River and Bradenton River, above the dams), provide 150% of the stormwater treatment required by SWFWMD MSSW rules. If the hypothetical 100-acre development that was provided stormwater treatment in the example in Section 2.1.1 was constructed in the headwaters of the Braden River, then the 277 lb/year nitrogen load reduction that would meet SWFWMD MSSW standards would be required to be increased to (277 x 1.5) 415 lb/year. However, if the development were new and subject to MSSW permitting anyway, then only the additional 50%, or 138 lb/year of nitrogen load reduction credit would be given.

Example 2

If a local government purchases a tract of environmentally-sensitive land, or otherwise precludes development of that land, credit would be given for the difference between the estimated TN loading from the land if developed, and the TN load generated by the land in its natural state. This would be calculated based on measured or literature data, with the potential loadings for the developed condition subtracted from the undeveloped condition loading to determine nitrogen load reduction credits.

A local government purchases a 100-acre parcel of natural forest habitat that is zoned for residential development and creates a wildlife preserve. The nitrogen load reduction credit for this management activity would be calculated as follows:

The per-acre TN load for undeveloped land in the Tampa Bay Watershed has been estimated to be approximately 1.15 lb TN/acre/year, as shown in Appendix A. The corresponding load for residential land is 4.52 lb TN/acre/year. Subtracting the two yields 3.37 lb TN/acre/year. For the 100-acre parcel, the total nitrogen load reduction credit equals 337 lb TN/year (100 acres x 3.37 lb TN/acre/year).

Alternately, the runoff coefficient (Appendix B) and TN concentration (Appendix C) can be used to estimate TN loading for the parcel under natural and developed conditions. This uses the same techniques as described in Section 2.1.1 above.

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APPENDICES

APPENDIX A

CCMP Land Use-Specific Nitrogen Loading Rates

Land Use-Specific Per-Acre Total Nitrogen Loadings (1992-94 average)			
Land Use Category	% Total Watershed TN Load	% Watershed Area	Yield (lbs TN/acre/year)
Residential	11	15.5	4.52
Commercial/Industrial/ Institutional	5	6.4	5.26
Mining	4	3.2	4.97
Range and Pasture	13	28.4	2.81
Intensive Agriculture (*)	6	6.5	5.63
Undeveloped Land	8	39.9	1.15

(*) Row crops, groves, feed lots, nursery, etc.

- from: TBNEP Comprehensive Conservation and Management Plan, 1997.

APPENDIX B

Land Use-Specific Runoff Coefficients

Seasonal Land Use-Specific Runoff Coefficients			
Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coefficient	Wet Season Runoff Coefficient
1) Single Family Residential	A	0.15	0.25
	B	0.18	0.28
	C	0.21	0.31
	D	0.24	0.34
2) Medium Density Residential	A	0.25	0.35
	B	0.30	0.40
	C	0.35	0.45
	D	0.40	0.50
3) Multifamily Residential	A	0.35	0.50
	B	0.42	0.57
	C	0.50	0.65
	D	0.58	0.75
4) Commercial	A	0.70	0.79
	B	0.74	0.83
	C	0.78	0.97
	D	0.82	0.91
5) Industrial	A	0.65	0.75
	B	0.70	0.80
	C	0.75	0.85
	D	0.80	0.90
6) Mining	A	0.20	0.20
	B	0.30	0.30
	C	0.40	0.40
	D	0.50	0.50

Seasonal Land Use-Specific Runoff Coefficients			
Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coefficient	Wet Season Runoff Coefficient
7) Institutional, Transportation Utils.	A	0.40	0.50
	B	0.45	0.55
	C	0.50	0.60
	D	0.55	0.65
8) Range Lands	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
9) Barren Lands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
10) Agricultural - Pasture	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
11) Agricultural - Groves	A	0.20	0.26
	B	0.23	0.29
	C	0.26	0.32
	D	0.29	0.33
12) Agricultural - Feedlots	A	0.35	0.45
	B	0.40	0.50
	C	0.45	0.55
	D	0.50	0.60

Seasonal Land Use-Specific Runoff Coefficients			
Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coefficient	Wet Season Runoff Coefficient
13) Agricultural - Nursery	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
14) Agricultural - Row and Field Crops	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
15) Upland Forested	A	0.10	0.15
	B	0.13	0.18
	C	0.16	0.21
	D	0.19	0.24
16) Freshwater - Open Water	A	0.80	0.90
	B	0.80	0.90
	C	0.80	0.90
	D	0.80	0.90
17) Saltwater - Open Water	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0
18) Forested Freshwater Wetlands	A	0.50	.60
	B	0.55	0.65
	C	0.60	0.70
	D	0.65	0.75

Seasonal Land Use-Specific Runoff Coefficients			
Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coefficient	Wet Season Runoff Coefficient
19) Saltwater Wetlands	A	0.95	0.95
	B	0.95	0.95
	C	0.95	0.95
	D	0.95	0.95
20) Non-forested Freshwater Wetlands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
21) Tidal Flats	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0

- from: Zarbock et al., 1994

APPENDIX C

Land Use-Specific Runoff Quality Concentrations

Land Use-Specific Nonpoint Source Water Quality Concentrations

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
1 (LDR)	Low Density Single Family Residential (SFR)	(1)	2.31	0.40	33.0
		(1)	2.14	0.32	28.0
		(1)	0.605	0.073	7.2
		(1)	1.18	0.307	3.5
		(1)	3.0	0.45	-
		(1)	2.2	0.25	-
		(4)	1.87	0.39	-
		(8)	1.46	0.401	19.0
		(9)	1.56	0.27	20.8
		(10)	2.04	0.593	49.7
		(11)	2.88	0.72	56.8
		min	0.605	0.073	3.5
		mean	1.93	0.380	27.3
		max	2.88	0.598	56.8
2 (MDR)	Medium Density Res. (See notes)	mean	2.04	0.44	33.5
3 (HDR)	Multifamily Residential	(1)	1.61	0.33	53.0
		(1)	2.57	0.45	36.8
		(1)	4.68	0.72	95.6
		(1)	1.91	0.73	-
		(1)	1.02	0.033	67.6
		(1)	1.91	0.51	14.3
		(4)	1.65	0.33	-
		(8)	2.05	1.34	29.0
		(9)	2.04	0.282	10.7
		(10)	2.05	0.150	8.3
		(11)	2.00	0.56	41
		min	1.02	0.033	8.3
		mean	2.14	0.49	39.6
		max	4.68	1.34	95.6

URBAN LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
4	Low Intensity Commercial	(1)	1.19	0.15	22.0
		(1)	1.10	0.10	45.0
	High Intensity Commercial	(1)	2.81	0.31	94.3
		(1)	3.53	0.82	-
		(1)	2.15	0.15	-
	Commercial (Office)	(8)	2.38	0.305	36.5
		(9)	1.08	0.495	50.6
		(10)	1.40	0.113	6.2
		(12)	1.05	0.145	13.8
	Commercial (Retail)	(8)	1.686	0.253	9.3
		(10)	1.28	0.177	14.5
		(11)	2.12	0.22	36.3
	Combined Commercial	min	1.05	0.10	6.2
		mean	1.82	0.27	32.9
		max	3.53	0.495	94.3
5	Industrial (light)	(1)	1.42	0.19	71.8
		(1)	1.42	0.31	102.0
		(4)	1.18	0.15	-
		(8)	2.28	0.332	18.2
		(9)	1.77	0.465	28.3
		(10)	1.92	0.490	84.3
		(11)	3.00	0.503	70.0
		min	1.18	0.15	18.2
		mean	1.85	0.349	62.4
		max	3.00	0.503	102
6	Mining	(4)	1.18	0.15	35 (e)
7	Institutional	(4)	1.18	0.15	35 (e)

AGRICULTURAL LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
10	Pasture	(1)	2.37	0.697	-
		(1)	2.48	0.27	8.6
		(2)	2.0	0.3	-
		(3)	3.0	0.25	-
		(4)	1.02	0.16	-
		(5)	5.1	3.2	-
11	Citrus	(7)	2.31	0.10	-
11,13	Citrus, Nursery	(4)	0.92	0.41	-
12	Feed Lot	(3)	29.3	5.1	-
		(3)	3.74	1.13	-
		(5)	26.0	5.1	-
14	Field & Row Crop	(2)	2.5	0.25	-
		(3)	2.5	2.5	-
		(4)	3.75	1.13	-
		(8)	2.97	2.35	12.7
Mixed Agricultural					
10,11	Citrus & Pasture	(1)	1.57	0.09	-
		(1)	1.33	0.09	4.6
		(1)	2.58	0.046	180
		(1)	2.68	0.562	-
		(1)	3.26	0.24	28.0
11,14	Citrus & Row Crops	(6)	1.78	0.3	5.6

(See following page for summarized agricultural water quality concentrations.)

SUMMARIZED AGRICULTURAL LAND USE DATA					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Rangeland	min	0.90	0.02	4.8
		mean	1.24	0.01	11.0
		max	1.47	0.21	17.3
10	Pasture	min	1.0	0.16	8.6
		mean	2.66	0.81	8.6
		max	5.1	3.2	8.6
11	Citrus	min	0.92	0.10	5.0
		mean	1.62	0.27	5.3
		max	2.31	0.41	5.6
12	Feed Lot	min	3.74	1.13	
		mean	19.7	3.8	50(e)
		max	29.3	5.1	
13	Nursery	mean	1.62(e)	0.27(e)	5.3(e)
14	Row Crop	mean	2.93	1.56	12.7

WATER/WETLAND AND FOREST/UNDEVELOPED LAND USES					
Land Use Classification			Land Use-Specific Water Quality Concentrations		
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)
8	Open Space/ Non-forested	(1)	1.38	0.07	17.3
		(1)	0.90	0.02	4.8
		(1)	1.47	0.07	-
		(4)	1.02	0.16	-
15	Upland Forest	(2)	0.1	0.007	-
		(3)	0.2	0.007	-
		(4)	1.02	0.16	-
16,17	Open Water	(1)	0.79	0.17	-
		(1)	0.73	0.04	0.00
		(1)	2.22	-	6.2
18,20	Freshwater Wetland	(1)	2.26	0.09	13.4
		(1)	1.02	0.16	-
		(1)	1.24	0.018	4.6
		(1)	1.88	0.33	12.7
		(4)	0.79	0.17	-
17	Saltwater		NA	NA	NA
19	Saltwater Wetlands		NA	NA	NA
21	Tidal Flats		NA	NA	NA

Notes:

- Concentrations for CLUCCS code 2 (MDR) are an average of CLUCCS codes 1 (LDR) and 3 (HDR).
- Concentrations for CLUCCS code 4 (Commercial) are an average of reported values for "low intensity" commercial, "high intensity" commercial, office, and retail.
- Estimated (e) values were based on data from similar land uses when no land use specific data were identified.
- Row crop data were often reported with other agricultural uses.
- Loadings from saltwater and saltwater wetlands were assumed to be zero.

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- from: Zarbock et al., 1994

APPENDIX D

Stormwater Best Management Practices - Range of Treatment Efficiencies

Best Management Practices treatment efficiencies, as used in the TBNEP Optimization Model, expressed as percent pollutant removed									
BMP Type	Total Nitrogen			Total Phosphorus			Total Suspended Solids		
	min	mean	max	min	mean	max	min	mean	max
Extended Detention Pond	10	30	60	30	60	90	5	48	90
Wet Pond	10	30	60	30	60	90	30	60	90
Constructed Wetland	0	25	40	10	35	65	75	75	75
Vegetated Swale	0	10	25	0	15	30	0	35	70
Vegetated Buffer Strip	0	35	70	0	45	90	20	50	80
Infiltration Basin	45	58	70	50	63	75	75	87	99
Exfiltration Trench	40	57	80	40	57	80	60	83	100

-from: Wade et al., 1997

APPENDIX E

AGRICULTURAL BEST MANAGEMENT PRACTICES APPLICABLE IN THE TAMPA BAY WATERSHED

Agricultural BMPs Applicable in the Tampa Bay Watershed

Agricultural BMPs applicable in the Tampa Bay watershed were identified using the "BMP Selector" from the Florida Cooperative Extension Service, IFAS, SP-15; the NRCS Field Office Technical Guide; and personal communications and discussions with Dr. Phyllis Gilreath, Cooperative Extension Service, Manatee County, Florida.

The following defines the BMPs identified as being most applicable to the agricultural land uses practices and physical settings in the Tampa Bay watershed. Table E-1 summarizes the BMPs and identifies the anticipated benefits according to agricultural land use. The anticipated benefits include nitrogen load reduction, pesticide load reduction, erosion control, and water conservation. The major agricultural land use types include row crops, citrus groves, and pasture and livestock. A number of the agricultural BMPs examined offer multiple benefits and can be implemented for more than one agricultural land use.

NUTRIENT CONTROL BMPs

Fencing - Fencing is the dividing or enclosing of land areas with a suitable permanent structure that acts as a barrier for livestock, game, or people. Fencing serves to: subdivide grazing land to permit use of planned grazing systems; exclude livestock or big game from plant communities that cannot withstand grazing; confine livestock or big game on an area; regulate access to areas by people and prevent trespassing; distribute grazing pressures more evenly thereby enhancing the quality of runoff water; and allow deferment periods to be incorporated with brush management practices thereby improving the efficiency of water use.

Fertigation - The delivery of fertilizer materials via an irrigation system.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the irrigator of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Absorption Wetland Use - This practice serves to provide, through use of existing wetland areas, an adequate land absorption area downstream from grazed areas so that soil and plants absorb nutrients and animal wastes.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting, reduces runoff and wind and water erosion, controls weeds, and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low-residue-producing crops are grown, on critical areas and on soils that have a low infiltration rate.

Nutrient Management - Nutrient management practices involve the managing of the amount, source, form, placement, and timing of applications of plant nutrients. It may include the management of plant nutrients associated with organic waste, commercial fertilizer, legume crops, and crop residues. Such practices can be applied to all lands to which materials containing plant nutrients are applied. Nutrient management practices serve to supply adequate plant nutrients for optimum (maximum economic) forage and crop yields, to minimize entry of nutrients to surface and ground water, and to maintain or improve the chemical and biological condition of the soil. Proper nutrient management practices reduce the availability of nutrients that could pollute surface or groundwater by managing the application method and amounts of nutrients applied to the soil.

The NRCS Field Office Technical Guide includes several planning considerations for proper nutrient management practices. It should be recognized that several other listed BMPs could be grouped as a nutrient management practice (e.g., waste utilization, soil testing, plant analysis, and timing and placement of fertilizers).

Rotational Grazing - Rotational grazing is a system in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years. The rest periods may be throughout the year or during the growing season of key plants. Rotational grazing serves several purposes, including: to maintain existing plant cover or hasten its improvement while properly using the forage of all grazing units; to improve water quality and reduce erosion; to increase grazing efficiency by uniformly using all parts of each grazing unit; to provide adequate forage throughout the grazing season; to improve forage quality and increase production; to enhance wildlife habitat; to promote flexibility in the grazing program and buffer the adverse effects of drought; and to promote energy conservation by using reduced amounts of fossil fuel.

Shade Areas - Shade areas serve to lessen the need for animals to enter water for relief from heat by using trees or artificial shelters to provide shade at selected locations. Such practices minimize animal contact with surface waters and thereby serve to protect surface waters from animal waste contamination. This practice may also serve to reduce erosional processes along stream banks due to reduced animal traffic.

Slow Release Fertilizer - The use of slow release fertilizers minimizes nitrogen losses from soils prone to leaching. Slow release fertilizer is used somewhat for strawberries and citrus crops in the Tampa Bay watershed.

Soil Testing and Plant Analysis - These practices involve testing of soil and plants to avoid overfertilization and subsequent losses of nutrients in runoff water.

Timing and Placement of Fertilizers - The proper timing and placement of fertilizers provides for maximum utilization by plants and minimum leaching or movement by surface runoff. The practice works well with drip irrigation systems. Citrus growers use split applications to save fertilizer.

Waste Management Systems - These are planned systems in which all necessary components are installed for managing liquid and solid waste, including runoff from concentrated waste areas, such that air, soil, and water resources are not degraded. The purpose of this practice is to manage waste in rural areas such that air, soil, and water resources are not degraded, and to manage waste in order to protect public health and safety. These systems should preclude pollutant discharges to surface or ground water and should recycle waste through soil and plants to the fullest extent practicable. The practice applies where: waste is generated by agricultural production; waste from municipal and industrial treatment plants is used in agricultural production; all practice components necessary to make a complete system are specified; and soil, water, and plant resources are adequate to properly manage waste. These systems may consist of a single component, such as a diversion, or may consist of several components. Examples of components that could be used in a waste management system include fencing, pond sealings or linings, subsurface drains, water storage ponds, waste treatment lagoons, and grassed waterways or outlets.

Waste Utilization - Waste utilization is the practice of using agricultural wastes and other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources. Waste utilization is a means to safely use wastes to provide fertility for crop, forage, or fiber production; to improve or maintain soil structure; to prevent erosion and to safeguard water resources. The practice involves the use of wastes for application to crops. Recommended waste application rate guidelines are listed in the NRCS Field Office Technical Guide. This practice may also include recycling of waste solids for animal feed supplement.

Water Table Management - Water table management or control is the practice of controlling the water table through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water. The practice improves the soil environment for vegetative growth by regulating the water table to remove excess runoff and subsurface water, facilitate leaching of saline or alkali soil, and regulate or manage ground water for subirrigation. The practice applies where: a high water table exists; topography is relatively smooth and flat; adequate water is available; the benefits of subirrigation, in addition to controlling ground water and surface runoff, justify system installation; soil depth and permeability will permit effective operation of the control system; saline or sodic soil conditions can be maintained of an acceptable level for efficient production of crops; a suitable outlet exists; and improvements for off-site water quality are needed and can be achieved through water table management techniques.

Water Tolerant Crops - This practice involves the careful selection of water-tolerant crops for organic soils so higher water tables can be maintained to reduce oxidation and release of nutrients to drainage water.

Water/Feeder Location - This practice involves the locating of feeders and watering facilities a reasonable distance from streams and water courses. The practice serves to reduce livestock concentrations, particularly near streams, and to encourage more uniform grazing. Properly locating watering and feeding facilities can improve surface water quality and reduce erosion around stream and creek banks.

WATER/IRRIGATION BMPs

Irrigation Water Conveyance - An irrigation water conveyance consists of a fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral. Irrigation water conveyances are used to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss. The practice is applicable to ditches and canals that serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservative use of soil and water resources on a farm or group of farms.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the irrigator of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Leveling (with Laser) - Land leveling is the practice of reshaping the surface of the land to be irrigated to planned grades. Land leveling permits uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging, yet at the same time provides for adequate surface or subsurface drainage. Soils should be deep enough so that after leveling work is completed an adequate and usable root zone remains that will produce satisfactory crop production with proper conservation measures. In the Tampa Bay watershed, land leveling is most important for crops utilizing seep irrigation systems.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting, reduces runoff and wind and water erosion, controls weeds, and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low-residue-producing crops are grown, on critical areas and on soils that have a low infiltration rate.

Pasture and Hayland Management - Pasture and hayland management involves the proper treatment and use of pastureland and hayland. The practice serves to prolong life of desirable forage species; to maintain or improve the quality and quantity of forage; and to protect the soil and reduce water loss. Pasture and hayland management practices can be used on all pastureland or hayland. An important aspect of these practices focuses on balancing fertilization according to production needs. Most Florida soils need fertilization to produce optimum yields of forage crops. Fertilization programs must consider the production needs and nutrient requirement of the forage crop, as well as the ability of the soil to retain and deliver nutrients and water. Although the NRCS Field Office Technical Guide provides specifications on fertilization of forage crops without the benefit of soil test results, the NRCS highly recommends the use of annual soil testing to assess fertilization requirements.

Pasture and Hayland Planting - Pasture and hayland planting practices primarily serve to establish forage plants on erodible soils to reduce runoff and erosion.

Prescribed Burning - Prescribed burning is the practice of applying fire to predetermined areas such that the intensity and spread of the fire are controlled. Prescribed burning practices control undesirable vegetation; prepare sites for planting and seedings; control plant diseases; reduce fire hazards; improve wildlife habitat, forage production, and forage quality; and facilitate distribution of grazing and browsing animals.

Range Seeding - Range seeding is the practice of establishing adapted plants by seeding on rangeland. Range seeding prevents excessive soil and water loss; produces more forage on rangeland or land converted to range from other uses; and improves the aesthetic quality of the grazing land. This practice is applicable on rangeland, native pasture, grazable woodland, and grazed wildlife land.

Trickle Irrigation System - A trickle irrigation system (e.g., spray jet irrigation or drip irrigation) is a planned system in which necessary facilities are installed for efficiently applying water directly to the root zone of plants via small diameter pipes, and by using special applicators (orifices, emitters, porous tubing, perforated pipe) operated under low pressure. The applicators may be placed on or below the ground surface. These systems maintain soil moisture within the range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation. The design of a trickle irrigation system is based on an evaluation of the site and the expected operating conditions. The soils and topography must be suitable for irrigation of the proposed crops, and the water supply must be sufficient in quantity and quality for the intended crops to be grown. Trickle irrigation is suited to most orchard (or grove) crops and row crops as well as for gardens, flowers, and shrubs in urban settings where small flow rates of water can be used efficiently. According to the NRCS's Technical Guide for agricultural BMPs, the field application efficiency of trickle irrigation systems may reach 90%.

Water Table Management - Water table management or control is the practice of controlling the water table through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water. The practice improves the soil environment for vegetative growth by regulating the water table to remove excess runoff and subsurface water, facilitate leaching of saline or alkali soil, and regulate or manage ground water for subirrigation. The practice applies where: a high water table exists; topography is relatively smooth and flat; adequate water is available; the benefits of subirrigation, in addition to controlling ground water and surface runoff, justify system installation; soil depth and permeability will permit effective operation of the control system; saline or sodic soil conditions can be maintained at an acceptable level for efficient production of crops; a suitable outlet exists; and improvements for off-site water quality are needed and can be achieved through water table management techniques.

Water Tolerant Crops - This practice involves the careful selection of water-tolerant crops for organic soils so higher water tables can be maintained to reduce oxidation and release of nutrients to drainage water.

PESTICIDE USE BMPs

Correct Pesticide Application - Correct pesticide application practices involve the responsible use of pesticides to minimize pesticide movement from the field where applications are made. Practices may include the spraying of pesticides when conditions for drift are minimal, mixing the pesticide properly with soil when specified, and avoiding applications when heavy rain is forecast.

Correct Pesticide Container Disposal - Correct pesticide container disposal practices refer to the use of the accepted methods for pesticide container disposal (such as those specified on the pesticide label).

Cultural Control of Pests - The cultural control of pests refers to using cultural practices, such as elimination of host sites and adjustment of planting schedules (i.e., crop rotation), to partly substitute for pesticides. The use of this practice should reduce the amount of pesticides introduced into the environment and thus protect surface and ground water quality from pesticide contamination.

Integrated Pest Management (IPM) - IPM practices encompass a variety of techniques to minimize or preclude the use of pesticides on agricultural crops. Practices include the use of crop rotation to reduce buildup of insects, the use of alternate control methods such as cover crops to foster populations of beneficial insects, the determination of economic pest thresholds, the adjusting of planting and harvest periods, and the use of field scouting. Additional components that may be part of an IPM program include the use of natural enemies and pheromones.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the irrigator of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Pesticide Selection - Proper pesticide selection practices refer to the selection of pesticides which are least toxic, persistent, soluble, and volatile as feasible for worker safety and protection of environment.

EROSION CONTROL BMPs

Conservation Cropping System - Conservation cropping is a system of growing crops in combination with needed cultural and management measures to improve the soil and protect it during periods when erosion occurs. Conservation cropping practices provide vegetative cover (often weed fallow) between crop seasons. The practice may include cover cropping and crop rotation.

Critical Area Planting - Critical area planting is the planting of vegetation such as trees, shrubs, grasses or legumes on critical areas. Critical area planting serves to stabilize the soil, reduce erosion and runoff to downstream areas, improve wildlife habitat, and enhance natural beauty. Applicable areas include sediment-producing, highly erodible or severely eroded areas, such as dams, dikes, ditches, mine spoil, levees, cuts, fills, surface-mined areas, and denuded or gullied areas where vegetation is difficult to establish with usual seeding or planting methods.

The NRCS Field Office Technical Guide includes detailed specifications for five categories of critical area plantings; they include:

342-I	Permanent Seedings;
342-II	Temporary Seedings;
342-III	Sod;
342IV	With Ground Cover, Vines, Shrubs and Other Plants; and
342-V	On Coastal Dune Areas.

Deferred Grazing - Deferred grazing practices postpone grazing for a prescribed period to improve vegetative conditions and reduce soil loss. Deferred grazing promotes natural revegetation by improving the health of the forage stand and permitting desirable plants to produce seed. Deferred grazing also serves to provide a feed reserve for fall and winter grazing or emergency use, reduce soil loss and improve water quality, and maintain or improve wildlife habitat. Deferred grazing practices which employ planned deferment periods can be applied to all rangeland, native pasture, grazable woodland, and grazed wildlife land. Planned deferment periods should be based on: the type of plants managed for, timing of "green-up" and active growth period, and plant vigor; the vigor and growth habits of the key forage species; weather and growing conditions; and the land user's goals. The planned deferment, however, must not cause overuse or have an adverse impact on the rest of the operating unit.

Fencing - Fencing is the dividing or enclosing of land areas with a suitable permanent structure that acts as a barrier for livestock, game, or people. Fencing serves to: subdivide grazing land to permit use of planned grazing systems; exclude livestock or big game from plant communities that cannot withstand grazing; confine livestock or big game on an area; regulate access to areas by people and prevent trespassing; distribute grazing pressures more evenly thereby enhancing the quality of runoff water; and allow deferment periods to be incorporated with brush management practices thereby improving the efficiency of water use.

Field Windbreak - A field windbreak is a strip or belt of trees (e.g., cedar tree wind blocks for potato farms) established in or adjacent to a field. Field windbreaks serve to reduce soil erosion from wind; conserve moisture; protect crops, groves, livestock, and wildlife; and increase the natural beauty of an area. Field windbreaks can be grown in or around open fields needing protection against wind damage, or where strips of trees or shrubs increase the natural beauty of an area or provide food and cover for wildlife.

Grassed Waterways or Outlet - This BMP includes natural or constructed channels or outlets that are shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. This BMP applies to natural or constructed channels that are to be established to vegetation and used for water disposal. Grassed waterways serve to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding, and to improve water quality. This practice is applicable to all sites where added capacity, vegetative protection, or both are required to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices. The practice should not be used where its construction would destroy important woody wildlife cover and where the present watercourse is not seriously eroding.

Irrigation Water Conveyance - An irrigation water conveyance consists of a fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral. Irrigation water conveyances are used to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss. The practice is applicable to ditches and canals that serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservative use of soil and water resources on a farm or group of farms.

Irrigation Water Management - The use of proper irrigation water management involves the determination and control of the rate, amount, and timing of irrigation water application in a planned and efficient manner through use of flow meters and potentiometers. The purpose of irrigation water management is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response and to minimize soils erosion, runoff, and fertilizer and pesticide movement, and to protect water quality. In order for the above stated purpose to be achieved, the irrigator of a conservation irrigation system must have the capability and knowledge to: determine when irrigation water should be applied based on the rate of water use by the crop and the stages of plant growth; measure or estimate the amount of water required for each irrigation, including the leaching needs; determine the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rates; adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of water to be applied; recognize erosion caused by irrigation; estimate the amount of irrigation runoff from an area; and evaluate the uniformity of water application.

Land Leveling (with Laser) - Land leveling is the practice of reshaping the surface of the land to be irrigated to planned grades. Land leveling permits uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging, yet at the same time provides for adequate surface or subsurface drainage. Soils should be deep enough so that after leveling work is completed an adequate and usable root zone remains that will produce satisfactory crop production with proper conservation measures. In the Tampa Bay watershed, land leveling is most important for crops utilizing seep irrigation systems.

Mulching - Mulching is the practice of applying plant residues, or other suitable materials not produced on the site, to the soil surface. Mulching conserves moisture, prevents surface compaction or crusting, reduces runoff and wind and water erosion, controls weeds, and helps establish plant cover. Mulching is applicable to soils subject to erosion on which low-residue-producing crops are grown, on critical areas and on soils that have a low infiltration rate.

Pasture and Hayland Management - Pasture and hayland management involves the proper treatment and use of pastureland and hayland. The practice serves to prolong life of desirable forage species; to maintain or improve the quality and quantity of forage; and to protect the soil and reduce water loss. Pasture and hayland management practices can be used on all pastureland or hayland. An important aspect of these practices focuses on balancing fertilization according to production needs. Most Florida soils need fertilization to produce optimum yields of forage crops. Fertilization programs must consider the production needs and nutrient requirement of the forage crop, as well as the ability of the soil to retain and deliver nutrients and water. Although the NRCS Field Office Technical Guide provides specifications on fertilization of forage crops without the benefit of soil test results, the NRCS highly recommends the use of annual soil testing to assess fertilization requirements.

Pasture and Hayland Planting - Pasture and hayland planting practices primarily serve to establish forage plants on erodible soils to reduce runoff and erosion.

Prescribed Burning - Prescribed burning is the practice of applying fire to predetermined areas such that the intensity and spread of the fire are controlled. Prescribed burning practices control undesirable vegetation; prepare sites for planting and seedings; control plant diseases; reduce fire hazards; improve wildlife habitat, forage production, and forage quality; and facilitate distribution of grazing and browsing animals.

Proper Grazing Use - Proper grazing use is the practice of grazing at an intensity which will maintain enough vegetative cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation. This practice serves to increase the vigor and reproduction of key plants; accumulate litter and mulch necessary to reduce erosion and sedimentation and improve water quality; improve or maintain the condition of existing vegetation; increase forage production; maintain natural beauty; reduce hazard of wildfire; and improve or maintain wildlife habitat. The practice is applicable on all rangeland, native pasture, and grazed wildlife land.

Range Seeding - Range seeding is the practice of establishing adapted plants by seeding on rangeland. Range seeding prevents excessive soil and water loss; produces more forage on rangeland or land converted to range from other uses; and improves the aesthetic quality of the grazing land. This practice is applicable on rangeland, native pasture, grazable woodland, and grazed wildlife land.

Rotational Grazing - Rotational grazing is a system in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years. The rest periods may be throughout the year or during the growing season of key plants. Rotational grazing serves several purposes, including: to maintain existing plant cover or hasten its improvement while properly using the forage of all grazing units; to improve water quality and reduce erosion; to increase grazing efficiency by uniformly using all parts of each grazing unit; to provide adequate forage throughout the grazing season; to improve forage quality and increase production; to enhance wildlife habitat; and to promote flexibility in the grazing program and buffer the adverse effects of drought.

Runoff Management System - This is a system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances such as the preparation of a field for a new crop. Proper runoff management serves to regulate the rate and amount of runoff and sediment from development sites during and after construction operations to minimize undesirable effects such as flooding, erosion, and sedimentation. Runoff management systems should be used to control runoff, erosion, and sedimentation to compensate for increased peak discharges and erosion resulting from construction activities. The practice involves the planning, design, installation, operation, and maintenance of runoff management systems, including adequate outlet facilities and components necessary for adequate management of storm runoff. Components may include dams, excavated ponds, exfiltration trenches, parking lot storage, rooftop storage, and underground tanks.

Shade Areas - Shade areas serve to lessen the need for animals to enter water for relief from heat by using trees or artificial shelters to provide shade at selected locations. Such practices minimize animal contact with surface waters and thereby serve to protect surface waters from animal waste contamination. This practice may also serve to reduce erosional processes along stream banks due to reduced animal traffic.

Water/Feeder Location - This practice involves the locating of feeders and watering facilities a reasonable distance from streams and water courses. The practice serves to reduce livestock concentrations, particularly near streams, and to encourage more uniform grazing. Properly locating watering and feeding facilities can improve surface water quality and reduce erosion around stream and creek banks.

Woodland Site Management - Woodland site management is the practice of managing soils and vegetation in woodland areas to encourage rapid growth of desirable trees in order to reduce soil erosion runoff.

Table E-1. Agricultural BMPs applicable in the Tampa Bay watershed including the problems addressed by agricultural land use type.

PROBLEM	NITROGEN LOADING			WATER USE/ IRRIGATION			PESTICIDE USE			EROSION		
LAND USE TYPE RC= Row Crop CG=Citrus Grove P/L=Pasture/Livestock	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L
BMP												
Conservation Cropping System										x		
Correct Pesticide Application							x	x				
Correct Pesticide Container Disposal							x	x				
Critical Area Planting										x	x	x
Cultural Control of Pests							x	x		x		
Deferred Grazing												x
Fencing			x									x
Fertigation	x	x		x	x							
Field Windbreak										x		
Grassed Waterways or Outlet			x									x
Integrated Pest Management							x	x	x			
Irrigation Water Conveyances				x	x					x	x	
Irrigation Water Management	x	x		x	x		x	x		x	x	
Land Absorption/Wetland Use			x									
Land Leveling (with Laser)				X								
Mulching	X			X						X		

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PROBLEM	NITROGEN LOADING			WATER USE/ IRRIGATION			PESTICIDE USE			EROSION		
LAND USE TYPE RC= Row Crop CG=Citrus Grove P/L=Pasture/Livestock	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L
Nutrient Management	X	X	X									
Pasture & Hayland Management			X			X			X			X
Pasture and Hayland Planting			X			X			X			X
Pesticide Selection							X	X				
Prescribed Burning						X						X
Proper Grazing Use												X
Range Seeding						X						X
Resistant Crop Varieties							X	X				
Rotational Grazing			X									X
Runoff Management System	X	X	X	X	X	X	X			X	X	X
Shade Areas			X									X
Slow Release Fertilizer	X	X	X									
Soil Testing & Plant Analysis	X	X	X									
Timing & Placement of Fertilizers	X	X	X									
Trickle Irrigation System				X	X							
Waste Management System			X									
Waste Utilization			X									
Water Table Management				X	X							
Water Tolerant Crops				X	X	X						
Water/Feeder Location			X									X

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LAND USE TYPE RC= Row Crop CG=Citrus Grove P/L=Pasture/Livestock	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L	RC	CG	P/L
Woodland Site Management												X