

APPENDIX VII

ESTIMATION OF NUTRIENT LOADS FOR WATERSHEDS IN THE CHOWAN BASIN

ESTIMATION OF NUTRIENT LOADS FOR FOUR NORTH CAROLINA SUBBASINS IN THE CHOWAN RIVER BASIN

Introduction

In 1979, after frequent and persistent algal blooms in the preceding years, the Environmental Management Commission adopted a Nutrient Sensitive Waters classification for the Chowan River. As a result of the of the reclassification NC DEM (Division of Environmental Management) produced the Chowan River Water Quality Management Plan (1982) which called for nutrient reduction goals of 20% for total nitrogen and 35% for total phosphorus. DEM also released 1990 update of the plan which stipulated that the 20% nitrogen reduction had been met and that a 29% reduction of total phosphorus had been achieved by 1989. (An in depth history of Chowan River nutrient management and algal bloom studies and reports is presented in Chapter 3 of this basin plan.)

At each subsequent update of the water quality management plan estimates of total nitrogen and phosphorus loading were developed for the basin. However, due to changing methods of estimating watershed wide nutrient loading, there is little or no opportunity for comparison between loading estimates. For purposes of the 1997 Chowan River Basinwide Water Quality Management Plan a comprehensive nutrient loading budget was developed for North Carolina portion of the watershed utilizing the most up to date methods and data that were available. The nutrient budget was developed to estimate nutrient loadings from the four DEHNR subbasins that comprise the Chowan basin, and for the basin as a whole.

Both point and nonpoint source loads are included in the nutrient budget. Point source loads represent the annual loading from permitted dischargers in the watershed under current conditions (1996). Nonpoint source loads represent the net export of nutrients from areas of varying land use within each watershed. These loads were calculated using an export coefficient model utilizing land cover information derived from LANDSAT data and nutrient export estimates derived from the literature. Atmospheric loadings were also calculated using export coefficients. The specific methodology used is discussed below.

Point Source Loads

~~Discharge monitoring data for the period from January to December, 1996 were obtained from the DWQ (Division of Water Quality) Compliance Monitoring System data base via FOCUS retrieval for all facilities in the basin. Average daily nitrogen and phosphorus loads for facilities with available N and P data were calculated in the process of the retrieval and multiplied by 365 to determine annual loads. Calculations and loads for all facilities are shown in Table VII-2.~~

Nonpoint Source Loads

The nutrient export coefficient approach (Reckhow et al, 1989; Novotny and Olem, 1994) calculates mass nutrient export from a given parcel of land as the product of land area and a unit load. The unit load, or nutrient export coefficient, is a measure of the nutrient export (mass load) per unit area per unit time, for example, pounds of N per acre per year). Unit loads will vary by the type of land cover and the nature of land use practices in a particular area. Numerous field studies have been conducted to estimate the amount of nitrogen and phosphorus entering surface waters from various land uses.

The land use/land cover data set used to develop the nutrient loading estimates discussed here was developed by the NC Center for Geographic Information and Analysis (CGIA) utilizing 1988 LANDSAT data. CGIA classified the Albemarle-Pamlico Estuarine Study area into 18 land use/land cover categories, as described by Khorram et al (1992). In the near future CGIA will release an updated land use/land cover data set based on 1993 LANDSAT imagery, but that information was not available in time for use in publication of this basin plan. The 1988 LANDSAT data was the most recent data suitable for characterizing land cover at the scale of subbasins.

The export coefficients used for the various land cover categories (Table VII-2) are based upon a recent study carried out by RTI (Research Triangle Institute) under a contract with the DCM (Steven Stichter, NCDCM, personal communication, 1995). The RTI project involved a literature review of nutrient export studies performed on the eastern piedmont and coastal plain, updating similar work conducted by RTI in 1992 (Dodd et al). The median or most likely values from the literature were used.

Forested areas include both natural and managed forests. It was not feasible to develop separate estimates for each forest type, and all forest and freshwater wetland categories were assigned the median forest values. Nutrient export from urban areas includes runoff from residential and commercial areas, industrial facilities, on-site wastewater disposal and solid waste facilities. The median export values for urban areas were assigned to all three categories of developed land because the land cover data could not distinguish between low, medium and high density developed areas with sufficient accuracy (see Khorram et al, 1992). Agricultural land includes row crops, pasture land and confined animal operations. However the land cover data could not distinguish between these types of agricultural activities, and the export coefficient used represents the median unit load from a cross-section of agricultural activities.

Atmospheric deposition includes wet and dry deposition of nutrients from all sources, including nitrogen from the burning of fossil fuels and ammonium from sources such as fertilizer and animal waste lagoons. Values for atmospheric deposition were taken from Dodd et al (1992) and are applied to open water as well as sand and salt marsh. This assumes that all nutrients falling on bare sand and salt marsh from atmospheric sources is exported to surface waters, and that on average no net export otherwise occurs from these areas.

As shown in Table VII-2, the detailed categories were aggregated into 4 major classes. Disturbed land was classified as agricultural because these areas were found to consist primarily of recently plowed fields (Khorram et al, 1992).

No land use/land cover data were available for some areas because of cloud cover or difficulty in classification. Such land was apportioned to the various land cover categories in proportion to the area of known land cover in each hydrologic unit. The amount of unclassifiable land was not significant (<1% of each hydrologic unit).

Discussion

The export coefficient approach has a number of limitations. Some of these are inherent in the method itself, while others result from the specific data used.

(1) The available land use/land cover information is based on 1988 data, and significant land use changes may have occurred in some areas since that time. Land use/land cover data for the 1993-1995 period is under development and will be available in March 1997. This data set should provide greater refinement in characterizing types of agricultural and urban areas.

(2) Land management practices can affect the export of nutrients from a given category of land use. The export coefficient approach does not take into account variations in loading resulting from different land management practices (such as no-till farming) on a localized basis.

(3) The export coefficients are not based upon site-specific studies of the Chowan River basin area, but rely on literature estimates. These estimates are based on studies conducted in the piedmont and coastal plain regions, but soils and other features of the study sites may differ from areas in the Chowan basin.

(4) Export estimates for urban areas do not explicitly account for inputs from septic systems or other on-site disposal systems such as spray irrigation systems for animal operations or municipalities.

(5) As mentioned earlier, the current land use data do not allow us to distinguish between types of agricultural activity, and it is thus not possible to separately evaluate loads from cropland, pasture and confined animal operations.

(6) The export coefficient approach does not take nutrient fate and transport into account, but rather, yields an estimate of the total nutrient load to surface waters within a watershed. It does not estimate the load exerted at any particular location. Only a portion of the nutrients which enter streams in the upper part of these watersheds will actually reach the estuarine sections of the river.

The use of export coefficients to estimate nutrient loads is the best method available given that detailed watershed models have not been developed for any of the areas examined here. Despite the limitations of this approach, the results provide a rough approximation of the loading to particular watersheds and indicate the general sources of that loading. As noted above, future applications of nutrient export methods to these watersheds will be enhanced by the acquisition of more recent and detailed land use/land cover data.

References Cited

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**TABLE VII-1
CALCULATED POINT SOURCE TP AND TN LOADS
CHOWAN BASIN**

PERMIT NUMBER	FACILITY NAME	SUB - BASIN	FLOW MGD	PERMITTED		AVERAGE		ANNUAL		AVERAGE		ANNUAL	
				FLOW MGD	MGD	TP LBS/DAY	TN LBS/DAY	TP LBS/YR	TN LBS/YR	TP LBS/DAY	TN LBS/DAY	TP LBS/YR	TN LBS/YR
NC0033782	GATES CO SCH - GATESVILLE ELEM	03-01-01	0.017	0.000	0.008	2.77	0.002	0.57					
NC0033791	GATES CO SCH - SUNBURY PRIMARY	03-01-01	0.022	0.003	0.209	76.35	0.037	13.58					
NC0033804	GATES CO SCH - T S COOPER ELEM	03-01-01	0.017	0.002	0.234	85.30	0.036	13.24					
NC0043974	GATES CO SCH - BUCKLAND ELEM	03-01-01	0.033	0.003	0.275	100.35	0.121	44.15					
	TOTAL LOAD					264.78		71.54					
NC0031330	NORTHAMPTON CO SCH-NCHS EAST	03-01-02	0.180	0.008	2.872	1048.23	0.484	176.76					
NC0003867	UNITED PIECE DYE WKS LP-EDENTO	03-01-03	9.000	1.008	101.244	36954.01	6.350	2317.65					
NC0020630	COLERAIN WWTP, TOWN OF	03-01-03	0.450	0.114	4.926	1797.82	0.986	359.71					
						38751.83		2677.36					

TABLE VII-2**EXPORT COEFFICIENTS USED IN CALCULATION OF
NONPOINT SOURCE LOADS, BY LANDSAT CATEGORY
(lb/ac/yr)**

Code	LANDSAT Category	TP Export	TN Export
URBAN		0.95	6.71
3	Low Density Developed		
4	Medium Density Developed		
5	High Density Developed		
AGRICULTURE		0.88	8.74
6	Agriculture, Bare Soil and Grass		
12	Disturbed Land		
FOREST		0.12	2.08
7	Low Density Vegetation		
8	Pine Forest		
9	Bottomland Hardwoods		
10	Hardwood Forest		
11	Pine/Hardwood		
14	Riverine Swamp		
15	Evergreen Hardwood/Conifer		
16	Atlantic White Cedar		
17	Low Pocosin		
ATMOSPHERIC DEPOSITION		0.58	11.06
2	Open Water		
18	Low Marsh		
19	High Marsh		

Source: NC Division of Coastal Management