SAMPLING PROGRAM FOR NUTRIENT TRANSPORT INTO SUBESTUARIES OF THE CHESAPEAKE BAY

prepared for

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1.0 INTRODUCTION

This report describes the preliminary design of sampling programs to characterize nonpoint pollutant transport into selected subestuaries of Chesapeake Bay. The proposed sampling programs are part of a comprehensive eutrophication study of the Bay sponsored through the cooperative efforts of the U.S. Environmental Protection Agency and the States of Maryland and Virginia. Specifications for the sampling program described herein have been coordinated with EPA, the States of Maryland and Virginia, and the consultant that is responsible for the sampling program on the subestuaries.

Data collected from the nonpoint sampling programs, in conjunction with data from estuarine sampling programs, will be the basis for calibration and verification of nonpoint source, stream, and estuarine water quality models. The data from the selected tributaries and subestuaries with representative soils and land use will be used to extrapolate model parameters for the entire region. The models will be the tools for analyzing nonpoint nutrient loadings and the impacts of land use changes and management practices on the eutrophication of Chesapeake Bay.

The preliminary design of the nonpoint sampling program includes the recommended period and frequency of sampling, constituents to be analyzed, sampling techniques, and guidelines for selection of sampling locations. These guidelines refer to the characteristics (size, soils, land use) of the sampled watersheds to insure representation of nonpoint loadings. Prior to implementation, a detailed design is needed to select specific watershed sites, sampling equipment, analytical techniques, and quality control specifications. The Chesapeake Bay Program has developed standard quality control specifications; analogous standards are needed for sampling equipment and analytical techniques to guarantee valid comparisons of data collected at the different sampling sites.

2.0 SELECTED WATERSHED AND SUBESTUARIES

The watersheds and subestuaries selected for the nonpoint sampling program include the Chester and Patuxent Rivers in Maryland and the Occoquan, Poquoson, and Ware Rivers in Virginia. Figure 1 shows the location of these watersheds and their outlets to Chesapeake Bay.

The Chester River is located on the eastern shore of Chesapeake Bay and drains an area of 440 sq mi. The watershed is predominantly agriculture with Coastal Plain soils and mostly tidal streams. The subestuary has experienced shellfish and aquatic plant problems, and is undergoing studies by the State of Maryland.

The Patuxent River is the largest of the chosen watersheds covering an area of 930 sq mi on the western shore of the Bay. The watershed includes upland streams, reservoirs, tidal streams, and a long estuary. Both Piedmont and Coastal Plain soils are represented in a variety of changing land uses. Portions of the watershed are heavily urbanized since it is located on the urban fringe of the Washington Metropolitan area. The river experiences high sediment and nutrient loads that impact the shellfish and finfish industries. Extensive studies are being conducted by various departments of the State of Maryland.

The Poquoson and Ware Rivers are the smallest of the selected watersheds draining areas of 21 sq mi and 67 sq mi, respectively, on the southwestern shore of Chesapeake Bay. The Poquoson is a branching estuary with mostly marsh, forest, and agricultural lands and some rapidly urbanizing areas. The Ware River watershed also is mostly tidal with forest and agriculture land use. Residential development is minimal. Both rivers experience high coliform counts and problems with septic tank waste. Shellfish beds are closed in both subestuaries. The Poquoson River is undergoing studies by the Virginia State Water Control Branch and other state agencies.

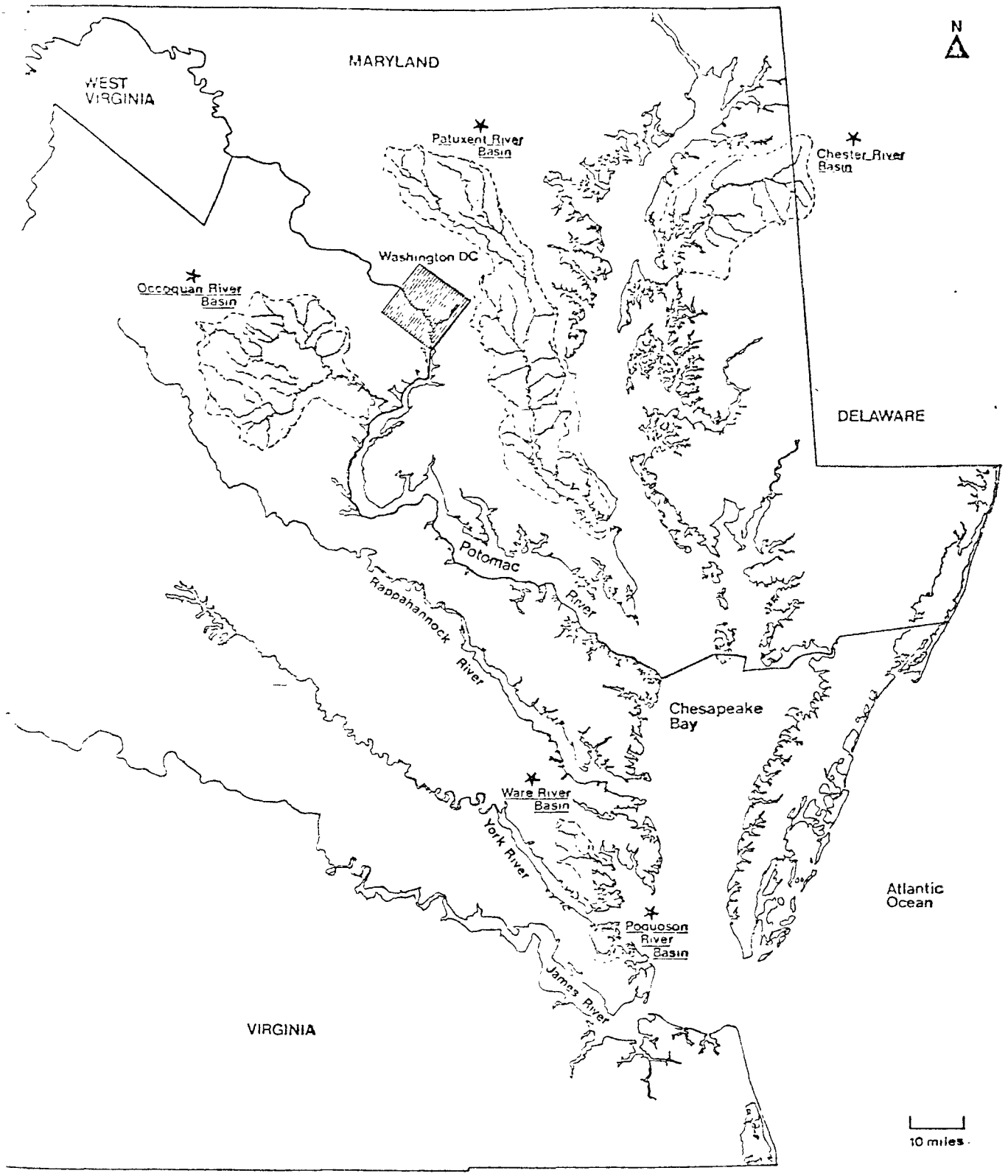

Figure 1. Locations of test watersheds

The Occoquan River drains 575 sq mi, including a large fresh water reservoir, before entering the Potomac River. The Piedmont soils of the Occoquan support several distinct land uses including forest, agriculture, high density residential, and commercial. Numerous point and nonpoint pollutant sources are present in the watershed which has been the subject of an extensive 208 study including water quality sampling and modeling.

3.0 NONPOINT SAMPLING PROGRAM DESIGN

A summary description of the recommended sampling program is provided in Table 1. The primary goal of the program is to characterize the nonpoint nutrient transport into subestuaries of Chesapeake Bay as part of the eutrophication study of the Bay. Although the resulting data will be used for other studies and analyses, the program was specifically designed for this purpose. Each of the major topics in Table 1 is discussed below.

3.1 Sampling Equipment

The central components of the sampling program are automated samplers designed to collect either a single volume-integrated sample or discrete samples by incremental charges in stage. The choice of a specific sampler will be made in the final program design. Continuous recording flow (stage) gages at each site will provide a continuous flow record and indicate the time period (or periods) when samples are obtained. Each site will include at least two continuous recording rain gages located at or near the sampling site and upstream within the drainage area of the site.

3.2 Land Use Sampling Site

Twelve sampling sites are recommended in each state distributed among the five watersheds and specific land uses as described in Table 1. Each sampling site should drain an area of at least 200 acres but not more than 1000 acres to insure that pollutant loads measured at the sites are derived from nonpoint sources alone without the interference of point sources and instream reactions. Each site should drain one dominant land use to allow extrapolation of pollutant loadings and model parameters.

The major land uses represented by the sampling sites include urban (residential, commercial, industrial), forests, pastures, idle land,

Table 1. SUMMARY DESCRIPTION OF THE SAMPLING PROGRAM FOR NONPOINT SOURCE TRANSPORT INTO CHESAPEAKE BAY

Equipment:
- Automatic samplers actuated by stage
- Continuous recording flow (stage) meters
- Recording rain gages at sampling site or upstream

Watershed/Land Use Sampling Sites:

Watershed	Land Use Sampling Sites
Chester River, MD - 6 sites	1 forest, 1 urban, 1 idle, 2 cultivated cropland (conservation and conventional tillage), 1 active pasture
Patuxent River, MD - 6 sites	3 urban (residential, commercial, and industrial), 1 forest, 1 pasture or idle, 1 cultivated cropland
Occoquan River, VA - 6 sites	1 forest, 1 idle, 2 cultivated cropland (conservation and conventional tillage), 1 pasture, 1 construction
Poquoson River, VA - 3 sites	2 urban (residential, commercial), 1 rural or idle
Ware River, VA - 3 sites	1 forest, 1 cultivated cropland, 1 urban

Sampling Site Size: 200 acres to 1000 acres

Downstream Sites: One downstream (main stem) sampling station of same design for each river.

Constituents:
- Nitrogen - Ammonia, Nitrate/Nitrite, Total Kjeldahl Nitrogen (or Organic Nitrogen)
- Phosphorus - Orthophosphate, Total Phosphorus
- Carbon - Total Organic Carbon, Carbonate, Bicarbonate
- Other - Total Suspended Solids, Total Solids (suspended and settleable), Carbonaceous BOD (20 days), COD (optional), DO (optional), Water Temperature (optional)

All nitrogen and phosphorus constituents measured on filtered and unfiltered samples.

Sampling Period and Frequency:

Two-year sampling period for all storms at each site.
Continuous flow and rainfall record for all storms.
Volume-integrated sample (by sampling equipment or in laboratory) for all storms for constituent analysis.
Detailed sampling for pollutograph definition for 2 to 5 storms per year.
Bimonthly grab sampling of low flows, analyzed for above constituents.
Inventory and selected sampling of point sources for characterization.

cultivated cropland (conservation and conventional tillage), and construction. The two dominant soil classifications in the five watersheds are the sandy Coastal Plain soils (Ware, Patuxent, Chester, Poquoson) and the Piedmont soils (Occoquan, Patuxent) with high silt and clay content. Thus, the sampling sites were distributed so that the major land use and soils combinations are represented. In the watersheds where septic tank problems exist (for example, Poquoson, Ware) the urban or idle land sampling sites should be chosen to include septic tank areas. The specific sites within each watershed will be selected in the final program design.

3.3 Downstream Sites

At least one sampling station is needed on the main stem of each river downstream of the land use sites. This station will be at a point that drains mixed land uses and will serve to integrate the separate nonpoint source loads from each land use. For the nontidal portions of the larger watersheds (that is, Occoquan, Patuxent), two or three stations will be needed to quantify instream reactions. However, existing sampling stations or previous data might be used for these purposes. In the Poquoson River Basin, the site should be replaced with a reservoir sampling site if the detention of the Harwoods Mill Reservoir is significant with respect to the entire travel time through the basin.

3.4 Constituents

The constituents to be analyzed are listed in Table 1. Nitrogen, phosphorus, and carbon constituents were selected because the primary emphasis of this study is eutrophication. Since Total Kjeldahl Nitrogen (TKN) is the sum of ammonia and organic nitrogen, the TKN test will be used for organic nitrogen since the ammonia component will be analyzed separately. All nitrogen and phosphorus constituents will be analyzed on both filtered and

unfiltered samples to determine the total and dissolved amounts.

Other recommended constituents include solids, BOD, COD, DO, and water temperature. Total suspended solids and total solids (suspended and settleable) are usually simulated by nonpoint models and are often the basis for simulating other pollutants. Total solids refers to the total particulate or sediment content, and particle size analysis (sand, silt, clay fractions) may be needed if detailed sediment modeling is executed. DO, carbonaceous BOD, and water temperature are conventional oxygen related constituents that should be measured; DO and water temperature are optional at the watershed sampling sites, but they should be measured at the downstream sampling stations. COD is usually a more reliable measure of oxygen demand so it is included as an optional check on BOD values. COD is not often simulated by water quality models.

Other constituents, such as coliforms and heavy metals may be added to the list at the discretion of the states if the data are to be used for analysis of problems other than eutrophication.

3.5 Sampling Period and Frequency

The sampling program is recommended for a continous 2-year period, sampling all storms at each site. Accompanying continuous rainfall and flow records are required. A volume-integration method of sampling is recommended to provide a single composite sample for each storm event at each site. The volume integration can be done manually in the laboratory or automatically by the field equipment, depending on the laboratory and equipment specifications as determined in the final design. The Chesapeake Bay region will usually experience 20-25 storms per year requiring samples.

In addition to the volume-integrated samples, detailed sampling for two to five storms per year is needed at each site to define the shape of the

pollutograph. This will require two to three samples collected on the rising limb of the hydrograph and two to three samples on the falling limb. Storms sampled in detail should also have volume-integrated samples to insure the accuracy and reliability of the volume-integration procedure. Storms for detailed sampling should occur in different seasons, and should follow different antecedent dry periods varying from 1 day to 1 to 2 weeks. This will allow investigation of varying pollutant accumulation and seasonal characteristics.

Bimonthly sampling of low flows analyzed for the same constituents is needed to characterize pollutant contributions from groundwater. Three to four days of stable flows should occur prior to sampling to insure a low flow condition. This sampling may not be possible on some small watershed sites that experience only storm-related runoff without a continuous baseflow.

Sampling major point source discharges will be required if sufficient data to characterize the discharge are not available on the constituents listed in Table 1. Minor point sources discharges can be characterized from industry type, manufacturing process, population (municipal effluent), etc.

4.0 GUIDELINES FOR PROGRAM MODIFICATIONS

The recommended sampling program should be reviewed and integrated with existing or anticipated programs in each watershed to eliminate any duplication of effort. Sampling stations operated by other state or federal agencies (for example, USGS, Forest Service) could replace or supplement the proposed station if the required constituents are analyzed. Any current instrumented sites should be primary candidates for the sampling sites as opposed to establishing new sites for this study.

If budgetary considerations require a reduction in scope, reducing the number of sampling sites is better than shortening the length of the sampling period. If sites are eliminated, all important land use/soils combinations should be represented in the reduced program in order to provide a basis for extrapolation of parameters to the entire Chesapeake Bay region. Additional economies can be realized by restricting detailed storm (pollutograph) sampling to selected sites (as opposed to all sites) with representative land use and soil characteristics.

The recommended sampling program provides a comprehensive framework for obtaining the nonpoint source data needed for the proposed eutrophication study of Chesapeake Bay. Reductions in the proposed design should be minimized to the extent possible. As mentioned previously, the final program design is needed prior to implementation to select specific watershed sites, sampling equipment, and laboratory and field procedures. This final design should include input from the sponsoring federal and state agencies, the modeling consultant, and the contractors for sampling and laboratory analyses.