OLD DOMINION UNIVERSITY

[1]Department of Biological Sciences
Old Dominion University, Norfolk, Virginia 23529

[2]Department of Chemistry and Biochemistry
Old Dominion University, Norfolk, Virginia 23529

[3]Chesapeake Bay Program Office
Virginia Department of Environmental Quality
Richmond, Virginia 23230

STATUS AND TRENDS IN WATER QUALITY AND LIVING RESOURCES IN THE VIRGINIA CHESAPEAKE BAY: JAMES RIVER (1985-2002)

Prepared by

Principal Investigators:

Dr. Daniel M. Dauer[1]
Dr. Harold G. Marshall[1]
Dr. John R. Donat[2]
Mr. Michael F. Lane[1]
Ms. Suzanne Doughten[1]
Mr. Frederick J. Hoffman[3]

Submitted to:

Chesapeake Bay Program Office
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23230

December 2003

OLD DOMINION UNIVERSITY

[1]Department of Biological Sciences
Old Dominion University, Norfolk, Virginia 23529

[2]Department of Chemistry and Biochemistry
Old Dominion University, Norfolk, Virginia 23529

[3]Chesapeake Bay Program Office
Virginia Department of Environmental Quality
Richmond, Virginia 23230

STATUS AND TRENDS IN WATER QUALITY AND LIVING RESOURCES IN THE VIRGINIA CHESAPEAKE BAY: JAMES RIVER (1985-2002)

Prepared by

Principal Investigators:

Dr. Daniel M. Dauer[1]
Dr. Harold G. Marshall[1]
Dr. John R. Donat[2]
Mr. Michael F. Lane[1]
Ms. Suzanne Doughten[1]
Mr. Frederick J. Hoffman[3]

Submitted to:

Chesapeake Bay Program Office
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23230

December 2003

Preface

This material in this report was produced for the Virginia Department of Environmental Quality in order to summarize patterns of status and trends in water quality, phytoplankton, primary productivity, zooplankton and benthos collected as part of the Virginia Chesapeake Bay Program. There are three reports, referred to as basin summaries, one each for the James River, the York River and the Rappahannock River. These basin summaries are intended to be electronic reports that will be periodically updated and they were intended for an audience already knowledgeable of the history and rationale of the program; design of the program; field and laboratory methods; specialized parameters, e.g. the Benthic Index of Biotic Integrity; status and trends analytical methods, etc.

In order to create a record of past patterns in status and trends and to make these data more widely available, a printed version of each basin summary was produced. To make the information more interpretable we have added an introduction and a methods section. However, this report is a data report and is not a comprehensive, interpretive report. Therefore, there is no discussion section to this report.

All three basin summaries and appendices are available at the Old Dominion University Chesapeake Bay Program website <www.chesapeakebay.odu.edu> under "Reports." The James River Report includes the Elizabeth River, the Chickahominy River and the Appomattox River. The York River Report includes the tidal Pamunkey River and Mattaponi River. The Rappahannock River Report includes the Corrotoman River. Also available at this website are appendices that include (1) tables of status for all parameters measured at all stations sampled by each program, (2) tables of all parameters and metrics for which there was a significant trend, and (3) scatter plots of all parameters over time. There are five appendices: water quality, phytoplankton, primary productivity, zooplankton and benthos.

Table of Contents

List of Appendices (on attached CD-ROM)

Summary

The Virginia Chesapeake Bay and its tidal tributaries continue to show some environmental trends indicating progress toward restoration of a more balanced and healthy ecosystem. However, the Bay system remains degraded and some areas and indicators show continuing degradation. Progress in reducing nutrient inputs has made demonstrable improvements and we expect that continued progress toward nutrient reduction goals, along with appropriate fisheries management and chemical contaminant controls, will result in additional improvements to the Bay. An overall summary of findings for the major VA Bay tributaries (i.e. James, York, and Rappahannock Rivers) is bulleted below while the remainder of this report focuses on the detailed results for the James River. Overall patterns of nutrient and sediment loads are summarized in Table 1.

- Nonpoint source loads (estimates of controllable and uncontrollable) of phosphorus, nitrogen, and sediment as calculated by the Bay Program Watershed Model, decreased by 7%, 9%, and 11%, respectively, compared to the 1985 baseline loads.

- Point source nutrient loads were reduced by 57% for phosphorus and 20% for nitrogen, compared to the 1985 baseline loads. This decrease in discharge may be partly due to ongoing drought conditions in Virginia.

- Combined nutrient loads were reduced by 26% for phosphorus and 13% for nitrogen, compared to the 1985 baseline loads.

- For phosphorus, there were improving trends above the fall-line at the river input stations of the James River, Appomattox River, Mattaponi River, and Rappahannock River with a degrading trend in the Pamunkey River. The improving trends are indicative of both point and nonpoint source nutrient reductions over the last 18 years. Both improving trends many degrading trends in phosphorus were detected were detected in the Virginia tributaries. Overall, there were 10 areas with improving trends and 11 areas with degrading trends in this parameter within the Virginia tributaries. Nearly half of those areas with improving trends in phosphorus were located in the Elizabeth River.

- For nitrogen, there were improving trends above the fall-line at the river input stations of the James River, Appomattox River, Mattaponi River and Rappahannock River and a degrading trend in the Pamunkey River. Overall, there were nine areas showing improving trends but only two areas showing degrading trends for nitrogen. Nitrogen levels showed improving trends in nearly segments all of the Elizabeth River.

- Chlorophyll *a* levels are moderately high throughout much of the tidal waters. Degrading trends were widespread geographically and indicative of detrimentally high nutrient levels. Overall, six areas showed degrading trends in chlorophyll *a* and four showed an improving trend. Every tributary had at least one degrading trend in chlorophyll *a* except the Elizabeth River.

- Water clarity, a very important environmental parameter, was generally fair or poor throughout the tributaries and degrading trends were detected five areas in the tributaries. This is probably related to high and scattered increasing levels of suspended solids. These degrading conditions in the Virginia Chesapeake Bay may result in degradation of zooplankton populations and are a major impediment to restoration of submerged aquatic vegetation (SAV). Overall, there were five areas showing improving trends and six areas showing degrading trends in water clarity.

- Levels of dissolved oxygen are improving in geographically widespread areas of the tidal rivers. Overall, there were 11 areas showing improving trends and no areas showing degrading trends for dissolved oxygen conditions. Dissolved oxygen conditions were good in most of the segments in the Virginia tributaries.

- The Virginia tributaries continue to contain favorable diatom populations that are generally dominant among the other flora in their abundance and biomass. However, there are increasing population trends among the cyanobacteria and dinoflagellates that are degrading and represent a less favorable phytoplankton population for these rivers. If these trends continue they would directly impact the trophic status and balance within the plankton community. Any increased development of dinoflagellate blooms within these rivers is another concern.

- Degrading trends and poor status of microzooplankton communities were observed in all of Virginia tributaries except the Elizabeth River. Most of the degrading trends and poor status occurred in the lower portions of each of the three major tributaries. Improving trends in the microzooplankton were observed in the Upper and Middle James River. Degrading trends in the microzooplankton may be related to degrading trends in nutrients and water clarity indicators and/or the decreasing trends in salinity observed in these regions.

- Benthic community patterns differed greatly between the rivers. In the James River there strong improving trends upstream and continued good status down stream. In the Elizabeth River there was a strong improving trend although the status of the benthic communities remains poor. In the York River and the Rappahannock River there are degrading trends in the middle reaches.

Table 1. Nutrient and Sediment Loads for Virginia (2001). Modified from data provided by the Virginia Department of Environmental Quality. Phosphorous and nitrogen loads are in kg/year and sediment loads are metric tons/year. Percent change compares 2001 data to 1985 data. Nonpoint source loads are results based on the Year 2000 Progress Run of Phase 4.3 of the Chesapeake Bay Watershed Model and calculated reductions for calendar year 2001 Best Management Practices (BMPs) as monitored by the Department of Conservation and Recreation. Values with a "*" were updated with the latest available point source data.

River Basin	2001 Phosphorus Load	Percent Change in Phosphorus	2001 Nitrogen Load	Percent Change in Nitrogen	2001 Sediment Load	Percent Change in Sediment
A. Nonpoint Loads						
Potomac	749,527	-10.5%	6,305,959	-10.1%	650,655	-13.4%
Rappahannock	396,532	-19.5%	3,372,686	-19.9%	297,812	-21.4%
York	297,250	-13.4%	3,089,427	-13.3%	126,172	-12.2%
James	2,037,523	- 0.8%	10,316,677	- 2.7%	1,085,925	- 5.4%
Coastal	88,295	-14.2%	943,327	- 5.0%	17,581	-17.2%
Totals	3,569,127	- 7%	24,028,077	- 9%	2,178,145	-11%
B. Point Source Loads. In parentheses is the number of significant point source discharges.						
Potomac (40)	251,218	-28%	5,336,045	+8%		
Rappahannock (14)	21,813*	-74%	246,721*	+11%		
York (9)	84,618*	-59%	502,801*	-20%		
James (30)	607,670*	-62%	6,974,083*	-44%		
Coastal (8)	66,482	-56%	826,527	+40%		
Totals	1,031,801	-57%	13,886,177	-20%		
C. Total Loads. All river basins combined.						
Nonpoint Source	3,569,127	-7%	24,028,077	-9%	2,178,145	-10.8%
Point Source	1,031,801	-57%	13,886,177	-20%		
Combined Loads	4,600,928	-26%	37,914,254	-13%	2,178,145	-10.8%

Chapter 1. Introduction

A marked decline in the water quality of the Chesapeake Bay has occurred over the past several decades. The disappearance of submerged aquatic vegetation in certain regions of the Bay, declines in the abundance of some commercially and recreationally important species, increases in the incidence of low dissolved oxygen events, changes in the Bay's food web, and other ecological problems have been related to the deteriorating water quality. The results of concentrated research efforts in the late 1970s and early 1980s stimulated the establishment of Federal and state directives to better manage the Chesapeake Bay watershed. By way of the Chesapeake Bay Agreements of 1983, the State of Maryland, the Commonwealths of Virginia and Pennsylvania, and the District of Columbia, agreed to share the responsibility for improving environmental conditions in the Chesapeake Bay. As part of this agreement, a long-term monitoring program in the Chesapeake Bay was established in order to: 1) track long-term trends in water quality and living resource conditions over time, 2) assess current water quality and living resource conditions, and 3) establish linkages between water quality and living resources communities. By tracking long-term trends in water quality and living resources, managers may be able to determine if changes in water quality and living resource conditions have occurred over time and if those changes are a reflection of management actions. Assessments of current status may allow managers to identify regions of concern that could benefit from the implementation of pollution abatement or management strategies. By identifying linkages between water quality and living resources it may be possible for managers to determine the impact of water quality management practices on living resource communities.

Water quality and living resource monitoring in the Virginia Mainstem and tributaries began in 1985 and has continued for 18 years. Detailed assessments of the status and long-term trends in water quality and living resources in Chesapeake Bay and its tributaries have been previously conducted (Alden et al., 1991,1992; Carpenter and Lane, 1998; Dauer, 1997; Dauer et al., 1998a,1998b, 2002; Lane et al.,1998; Marshall, 1994,1996; Marshall and Burchardt, 1998; Marshall et al., 1998). An attempt was made to determine if there was concordance in current conditions of, and long-term changes, in water quality and living resources. The purpose of this project was to reassess the results of these studies by re-conducting the analyses after adding data collected during 2002. This report describes the status of water quality and living resource conditions for the Virginia Mainstem and tributaries, summarizes major long-term trends in water quality and measures of living resource community health.

Chapter 2. Monitoring Program Descriptions

I. Water Quality

A. Sampling Locations and Procedures

As part of the U. S. Geological Survey's River Input Program, water quality data have been collected at five stations near the fall line and three stations above the fall line in Virginia. Samples were taken at base-flow twice a month and during high flows whenever possible between 1988 and 2002. Water quality data have also been collected by the Virginia Department of Environmental Quality (DEQ) at three additional stations upstream of these River Input sites (Figure 2-1). These stations had a minimum of three consecutive years of samples taken between 1985 and 1996 with sampling occurring on at least a monthly basis.

Water quality conditions were regularly monitored at 28 sites in the Bay Mainstem beginning in July, 1985. From 1985 until 1995 eight stations were sampled by Old Dominion University (ODU) and 20 stations were sampled by the Virginia Institute of Marine Science (VIMS). From 1995 through the present, Mainstem water quality monitoring was conducted by ODU. Tributary water quality monitoring was conducted by the Virginia DEQ at 27 sites in the James, York (including the Mattaponi and Pamunkey) and Rappahannock rivers (Figure 2). In addition, six permanent water quality monitoring sites were established in the Elizabeth River/Hampton Roads Harbor by ODU in February, 1989 (Figure 2-2). In August 1990, station LAF1 was dropped from the Elizabeth River Long Term Monitoring (ERLTM) Program.

The temporal sampling scheme for the water quality monitoring program changed several times over the 18 year period (varying from 20 to 12 sampling events per year) as a result of changes in the monitoring program budget. In general, Mainstem sampling cruises were conducted semi-monthly from March through October and monthly from November through February until 1996. Starting in 1996 Mainstem sampling cruises were conducted semi-monthly for July and August and monthly the rest of the year. Tributary sampling by the Virginia Department of Environmental Quality was generally conducted 20 times per year. The Elizabeth River stations were sampled monthly. Field sampling procedures used for ODU and VIMS water quality collections are described in detail by Alden et al. (1992a). Field sampling procedures for DEQ water quality collections are described in detail in DEQ's Quality Assurance Project Plan for the Chesapeake Bay Program (Donat and Doughten, 2002).

B. Laboratory sample processing

Descriptions of laboratory sample processing and standard operating procedures for all water quality parameters are found in the Chesapeake Bay Program Quality Assurance Project Plans (QAPjPs) prepared by each of the participating laboratories (Donat and Doughten, 2002). Copies of the QAPjPs can be obtained by contacting EPA's Chesapeake Bay Program Quality Assurance Officer.

II. Phytoplankton

A. Sampling Locations and Procedures

Seven stations were established in Chesapeake Bay in July 1985. These were CB6.1, CB6.4, CB7.3E, CB7.4, LE5.5, WE4.2, and LE3.6 (Figure 2-3). From July, 1985 through September, 1990, phytoplankton collections were taken from these stations twice a month from March through October, and monthly November through February. From October, 1990, monthly samples were taken at all Bay stations. Monthly sample collections and analysis in the James (TF5.5, RET5.2), York (RET4.1, RET4.3), and Rappahannock (TF3.3, RET3.1) rivers began in March, 1986. In March, 1987, station RET4.1 in the Pamunkey River was replaced by station TF4.2, and in February, 1989, monthly collections began at two stations (SBE2, SBE5) in the Elizabeth River. Picoplankton analysis was included at several trial stations in January, 1989, and was expanded to include all stations in July, 1989. Primary production analysis was added to all Bay and tributary stations in July 1989.

At each station, two vertical sets of three liter water samples were taken at five equidistant depths above the pycnocline and placed in two separate carboys. The process was repeated at five depths below the pycnocline. The water in each carboy was carefully mixed and replicate 500 ml sub-samples were removed from each carboy, and fixed with Lugol's solution. A second set of 125 ml sub-samples were also taken above and below the pycnocline, preserved with glutaraldehyde and placed in a cooler. These samples were taken to determine the concentrations of the autotrophic picoplankton population. An additional replicate set was also taken from the same carboy set taken above the pycnocline for primary productivity measurements.

B. Laboratory Sample Processing

Samples for phytoplankton analyses were passed through a series of settling and siphoning steps to produce a concentrate (or fraction of the concentrate) that was examined using a modified Utermöhl method with an inverted plankton microscope (Marshall and Alden, 1990). The analysis procedure attained an estimated precision of 85% (Venrick, 1978). The autotrophic picoplankton were processed through a protocol that included their collection on a 0.2 µ nucleopore filter, with subsequent analysis using an epifluorescent microscope, under oil at 1000x magnification, with "green" and “blue” filter sets (Marshall, 1995). Supplemental analysis with a scanning electron microscope was used in several of the species identifications. Methodology for the productivity measurements is given in Marshall and Nesius (1996). Appropriate quality assurance/quality control practices in sample collection, analysis, and data entry were employed throughout this period.

III. Microzooplankton

A. Sampling Locations and Procedures

Microzooplankton communities were monitored monthly at seven sites in the Mainstem and six sites in the Virginia tributaries beginning in January, 1993 (Figure 2-3). Whole water samples were collected at all stations. Before sampling, 10 ml of modified Lugol's solution was placed into two liter (L) bottles designated for each station. The water was sampled through the use of a battery powered pump attached to a hose. Two composite water samples, each totaling 15 L, were taken from five equidistant depths above the pycnocline and collected in two carboys. Each carboy was thoroughly mixed and 1 L taken from each (Samples A and B for each station).

B. Laboratory Sample Processing

The whole water samples taken for microzooplankton (<200μ) analysis were processed through a screen, plus a series of settling and siphoning procedures (Park and Marshall, 1993). These steps removed the larger zooplankters and debris to provide 3 sub-sets based on size to be analyzed. This method insured the collection and analysis of the small non-loricated ciliates to be included in the count.

IV. Benthos

A. Fixed Location Sampling

Sixteen stations in the lower Chesapeake Bay were sampled quarterly (March, June, September, December) from March 1985 through December 1995 as part of the Benthic Biological Monitoring Program of the Chesapeake Bay Program. Beginning in 1996 sampling at the fixed stations occurred only in June and September and a stratified random sampling element was added to the program. Power and robustness analyses indicated that sampling during June and September would be sufficient for detecting long-term trends at the fixed locations while at the same time, allow funding resources to be reallocated to the probability-based random sampling regime (Alden et al., 1997). Stations were located within the mainstem of the bay and the major tributaries - the James, York and Rappahannock rivers (Figure 2-3). In the tributaries, stations were located within the tidal freshwater zone (TF5.5, TF4.2, TF3.3), turbidity maximum (transitional) zone (RET5.2, RET4.3, RET3.1), lower estuarine mesohaline muds (LE5.2, LE4.1, LE3.2) and lower estuarine polyhaline silty-sands (LE5.4, LE4.3). The tidal freshwater station within the York River estuary was located in the Pamunkey River. In the Mainstem of the Bay three stations were located off the mouths of the major tributaries (CB8.1, CB6.4, CB6.1) and two stations in the deeper channels near the bay mouth (CB7.3E) and above the Rappahannock River near the Virginia-Maryland border (CB5.4).

In 1989, five additional stations were added to the program: two stations in the Southern Branch of the Elizabeth River (SBE2, SBE5) in regions exposed to contaminated sediments, a station in the transitional region of the James River (LE5.1), a station in the lower York River exposed to low dissolved oxygen events (LE4.3B), and a station in the lower Rappahannock River exposed to low dissolved oxygen events (LE3.4).

For the fixed point stations three replicate box core samples were collected for benthic community analysis. Each replicate had a surface area of 184 cm^2, a minimum depth of penetration to 25 cm within the sediment, was sieved on a 0.5 mm screen, relaxed in dilute isopropyl alcohol and preserved with a buffered formalin-rose bengal solution.

At each station on each collection date a 50g subsample of the surface sediment was taken for sediment analysis. Salinity and temperature were measured using a Beckman RS5-3 conductive salinometer and bottom dissolved oxygen was measured using a YSI Model 57 oxygen meter. For the original 16 stations see Dauer et al. (1992) for a summary of the pattern of bottom oxygen values, Dauer et al. (1993) for a summary of the distribution of contaminants in the sediments and Dauer (1993) for a summary of salinity, water depth, and sedimentary parameters.

B. Probability-based Sampling

In 1996 a probability-based sampling program was added to estimate the area of the Virginia Chesapeake Bay and its tributaries that met the Benthic Restoration Goals as indicated by the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997; Alden et al., 2002). Four strata were defined and each stratum was sampled by 25 randomly allocated sites. The four strata were: 1) the James River; 2) the York River (including the Pamunkey and Mattaponi rivers); 3) the Rappahannock River; and 4) the Mainstem of the Chesapeake Bay. Each year a new set of 25 random sites was selected for each stratum.

Probability-based sampling within strata supplements data collected at fixed-point stations. Sampling design and methods for probability-based sampling are based upon those developed by EPA's Environmental Monitoring and Assessment Program (EMAP, Weisberg et al., 1993) and allow unbiased comparisons of conditions between strata (e.g., tributaries) of the Chesapeake Bay within the same collection year and within tributaries for between different years. The consistency of sampling design and methodologies for probability-based sampling between the Virginia and Maryland benthic monitoring programs allows bay-wide characterizations of the condition of the benthos for the Chesapeake Bay (Dauer 1999; Dauer and Rodi 1998a, 1998b, 1999, 2001, 2002).

Within each probability-based stratum, 25 random locations were sampled using a 0.04 m^2 Young grab. At each station one grab sample was taken for macrobenthic community analysis and a second grab sample for sediment particle size analysis and the determination of total volatile solids. All sampling processing for probability-based sampling stations were identical to those for the fixed stations. Physico-chemical measurements were also made at the random locations.

C. Laboratory Sample Processing

In the laboratory, each replicate was sorted and all the individuals identified to the lowest possible taxon and enumerated. Biomass was estimated for each taxon as ash-free dry weight (AFDW) by drying to constant weight at 60 °C and ashing at 550 °C for four hours. Biomass was expressed as the difference between the dry and ashed weight.

The sand fraction of each sediment sample was dry sieved and the silt-clay fraction was quantified by a pipette analysis using the techniques of Folk (1974). Total volatile solids for each sediment sample was determined as the AFDW weight of the sediment divided by the dry weight of the sediment, expressed as a percentage.

V. Statistical Analyses

In order to ensure that long-term trends in water quality and living resource data are correctly interpreted, a unified approach for conducting the statistical analyses and interpreting their results was developed. Statistical analytical procedures used in this study were based on guidelines developed by the CBP Monitoring Subcommittee's Tidal Monitoring and Assessment Workgroup. For both status and trend analyses, the stations were grouped into segments based on the segmentation scheme developed by the Data Analysis Workgroup (Figure 2-2). Status and trend analyses were conducted for different time periods or "seasons" as defined for each monitoring component in Table 2-1.

A. Status Assessments

For the tidal water quality stations, status analyses were conducted using surface and bottom water quality measurements for six parameters: total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a*, and total suspended solids. Status analyses were also performed on secchi depth and bottom dissolved oxygen. All analyses were conducted using water quality data collected from all of the Chesapeake Bay Mainstem and tributary collection stations from the January 2000 through December of 2002 except for bottom dissolved oxygen for which analyses were conducted using data collected only during the summer months of June through September.

The relative status of each station and segment was determined by comparison to a benchmark data set comprised of all data collected from 1985 to 1990 by both the Virginia and Maryland monitoring programs. Each station was rated as poor, fair, or good relative to the benchmark data. The ratings are obtained for data collected within each salinity zone with salinity zones being assigned using the Venice classification system (Symposium on the Classification of Brackish Waters, 1958). For each parameter in the benchmark data set, a transformation was chosen that yields a distribution that was symmetric and approximated by the logistic cumulative distribution function (CDF). In most cases, the logarithmic transformation was selected. A logistic CDF based on the mean and variance of each parameter of the benchmark data set was used to perform a probability integral transform on all data collected during the period of January, 2000 through December, 2002. This resulted in data in the interval (0,1) that follow a uniform distribution. The three year median of these transformed data was computed as an indicator of status for the period specified. The median of n observations taken from a uniform distribution follows a Beta distribution with parameters (m,m) where:

$$m = (n+1)/2$$

and n is the number of observations. The transformed three year medians were compared to the Beta density distribution and status was determined by the placement of the transformed medians along the distribution. If the median was in the upper third of the distribution (where upper is chosen as the end of the distribution that is ecologically desirable) then the status rating is good, while a median in the middle third was rated fair, and a median in the lower third was rated poor. In most cases, serial dependence of the raw data resulted in greater than expected variance in the Beta density of the medians. To adjust for this, the variance of the Beta density was increased by a function of the ratio of among station variance to within station variance.

Because sampling regimes between monitoring programs varied with respect to the number of collection events within a given month and the number of replicate samples collected at each station varied, a uniform calculation protocol was adopted for use by both states to insure that the calculations were not inadvertently biased by these discrepancies. First, replicate values were combined by calculating a median for each station date and layer combination. Median values for each station month and year combination were calculated to combine separate cruises per month. Finally, station specific or segment specific median scores were calculated that were compared to the benchmark scale.

Water quality data were also assessed to determine if the SAV habitat requirements were met for the following parameters: chlorophyll *a*, total suspended solids, secchi depth, dissolved inorganic nitrogen, and dissolved inorganic phosphorus. Three year medians for the SAV growing season were compared to the SAV habitat requirement values (see Table 2-2) using a Mann-Whitney U-test. If the median values were significantly higher than the habitat requirement for that parameter then the parameter was considered to have failed to met the SAV habitat requirements and if the values were significantly lower (higher for secchi depth) than the habitat requirement then the parameter was to considered to have met the SAV habitat requirement. If there was no significant difference between the habitat requirements or there were insufficient data to conduct the analysis, the parameter was considered borderline.

Status for phytoplankton, and microzooplankton involved the calculation of relative status using the same technique as described for water quality relative status assessments. For phytoplankton communities the following indicators were assessed: total phytoplankton community abundance, total phytoplankton community biomass, diatom abundance, dinoflagellate abundance, cyanobacteria abundance, picoplankton abundance, and primary productivity (carbon fixation). Benchmarks for picoplankton abundance were made using data collected only in Virginia since sampling protocols for the Maryland program did not include counts of epifluorescent picoplankton. Microzooplankton parameters assessed included copepod nauplii abundance and rotifer abundance.

Status of benthic communities at each station was characterized using the three-year mean value (2000 through 2002) of the B-IBI (Weisberg et al., 1997). The B-IBI indicates whether the macrobenthic community meets the restoration goals developed for benthic habitats of the Chesapeake Bay. An index value that exceeds or equals 3.0 indicates that the macrobenthic community meets or exceeds the restoration goals developed for that habitat type while a value below 3.0 indicates that the macrobenthic community does not meet the restoration goals. Status of the benthic community was classified into four levels based on the B-IBI. Values less than or equal to 2 were classified as severely degraded, values from 2.0 to 2.6 were classified as degraded, values greater than 2.6 but less than 3.0 were classified as marginal, and values of 3.0 or more were classified as meeting goals.

B. Long-term Trend Analyses

1. Non-tidal water quality

Trend analyses were conducted on data collected at nine stations at and above the fall-line in the Virginia tributaries. Concentrations of water-quality constituents are often correlated with streamflow. Removal of natural flow variability allows examination of changes in water quality resulting from human activities. Flow-adjusted concentration trends were determined with a non-parametric Kendall-Theil analysis. The trend slope was the overall median of the pairwise slopes of residuals from a log-linear-regression model incorporating flow and season terms. For data sets with greater than five percent censored data, a range in slope and magnitude was defined by twice computing the median slope - first, with censored data equal to zero and second, with censored data equal to the maximum detection limit. For data sets with greater than twenty percent censored data, no results were reported. A p-value of 0.05 or less was considered significant for this analysis.

When considering the health of living resources, it is necessary to examine trends in concentrations that may be both flow- and human-induced. These concentrations were weighted, but not adjusted, for flow. The flow-weighting resulted in a more representative monthly concentration than the one point per month typical of many observed data sets. The volume of flow occurring between these infrequent sample dates is likely to have a pronounced effect on average concentrations in the tidal estuaries and other mixed receiving areas. Therefore trends in flow-weighted concentrations may correlate better with trends in estuarine concentrations. The linear trend in flow-weighted concentration was estimated by regressing flow-weighted concentrations with time. In most cases, the data was log-transformed in order to meet the assumptions of normality, constant variance, and linearity. A p-value of 0.01 or less was considered significant for this analysis.

2. Tidal water quality

Trend analyses were conducted on the same suite of water quality parameters used for the status assessments and salinity and water temperature. Prior to the trend analyses, data were reduced to a single observation for each station month and layer combination by first calculating the median of all replicates for each layer by station and date and then calculating the median between all dates for a given station within each month. For all applicable water quality parameters, any values less then the highest detection limit were set to one half of the highest detection limit. For calculated parameters, each constituent parameter that was below the detection limit was set to one half of the detection limit and the parameter was then calculated.

Increasing trends in total nitrogen, dissolved inorganic nitrogen, total phosphorus, dissolved inorganic phosphorus, chlorophyll *a* and total suspended solids should indicate increased eutrophication and as a result positive slopes in these parameters indicate degrading conditions while negative slopes indicate improving water quality conditions. Increasing trends in secchi depth and bottom dissolved oxygen indicate increasing water clarity and reduced eutrophication, respectively and, as a result, indicate improving water quality conditions. Decreasing trends in these two parameters indicate degrading conditions.

In 1994, changes in analytical methods for estimating concentrations of total nitrogen, dissolved inorganic nitrogen, total phosphorus and dissolved inorganic phosphorus were implemented by the Department of Environmental Quality in order to improve the accuracy of concentration estimates. These changes resulted in step trends in these parameters. In order to compensate for the step trends, a "blocked" seasonal Kendall approach (Gilbert, 1987) was used to compare trends conducted between two separate time periods which in this case were the pre-method (1985 through 1993) and post-method change (1995 through 2002) time periods for these parameters. Note that 1994 was eliminated from the analyses because samples during this year were collected and processed by laboratory that was different than the DEQ. The "blocked" seasonal Kendall test was applied only to those segment/parameter combination for which a method change occurred. The statistical tests used for all other segment/parameter combinations were the seasonal Kendall test for monotonic trends and the Van Belle and Hughes tests for homogeneity of trends between stations, seasons, and station-season combinations (Gilbert, 1987).

A p value of 0.05 was chosen as the statistical test criterion for all water quality trend analyses. Recent studies on representative data sets from the Chesapeake Bay monitoring program have indicated that these tests are very powerful and robust, even when data violate most of the assumptions of parametric statistics (Alden et al., 1991; Alden et al., 1992b; Alden et al., 1994; Alden and Lane, 1996).

3. Living resources

Trend analyses for phytoplankton communities were conducted on the following phytoplankton community indices: the phytoplankton IBI, total phytoplankton abundance (excluding picoplankton);

total phytoplankton biomass (excluding picoplankton); the Margalef species diversity index, and C^{14} productivity. In addition, trend analyses were conducted on abundance and biomass values for the following taxonomic groups: diatoms; dinoflagellates; cyanobacteria; cryptomonads; chlorophytes; bloom producing species; and toxic bloom producing species.

The Margalef species diversity index was calculated as follows:

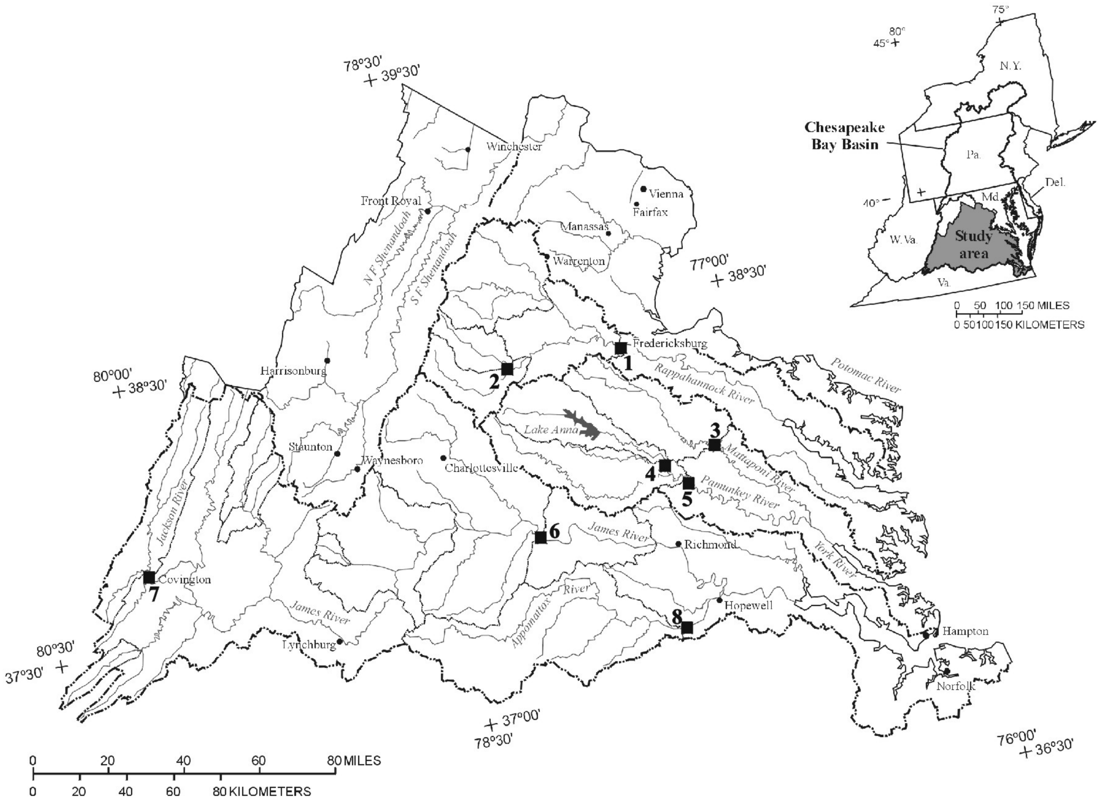
$$D = \frac{S - 1}{\log_2 N}$$

where *S* is the number of taxa in the sample and *N* is the number of individuals (Margalef, 1958).

Trend analyses for microzooplankton communities were conducted by station using monthly medians of microzooplankton collected from the beginning of the monitoring program through December of 2002. Microzooplankton bioindicators used for the trend analyses included: total microzooplankton abundance, rotifer abundance, copepod nauplii abundance, oligotrich abundance, tintinnid abundance, sarcodinia abundance, and microzooplankton cladoceran abundance.

Trend analyses for benthic communities were conducted using the B-IBI (Ranasinghe et al., 1994; Weisberg et al., 1997) and on selected metrics of the B-IBI. Benthic restoration goals were developed for benthic habitats of the Chesapeake Bay based upon reference sites that were minimally impacted by low dissolved oxygen events and sediment contaminants. Goals were developed based upon data from an index period of July 15 through September 30. Therefore trends in the value of the B-IBI were based upon September cruise values for the 17 year period of 1985-2002. Selected benthic metrics were species diversity (H'), community abundance, community biomass, pollution-indicative species abundance, pollution-indicative species biomass, pollution-sensitive species abundance, and pollution-sensitive species biomass. See Weisberg et al. (1997) for a list of pollution-indicative and pollution-sensitive taxa.

The statistical tests used for the living resources bioinidcators were the seasonal Kendall test for monotonic trends and the Van Belle and Hughes tests for homogeneity of trends between seasons (Gilbert, 1987). Statistical test criterion for the phytoplankton and microzooplankton was a p value of 0.05 while the criterion for the benthic bioindicators was a p value of 0.10.



1 Station 01668000 - Rappahannock River near Fredericksburg
2 Station 01666500 - Robinson River
3 Station 01674500 - Mattaponi River near Beulahville
4 Station 01671020 - North Anna River near Doswell
5 Station 01673000 - Pamunkey River near Hanover
6 Station 02035000 - James River at Cartersville
7 Station 02013100 - Jackson River at Covington
8 Station 02041650 - Appomattox River

Figure 2-1. Locations of the USGS sampling stations at and above the fall-line in each of the Virginia tributaries.

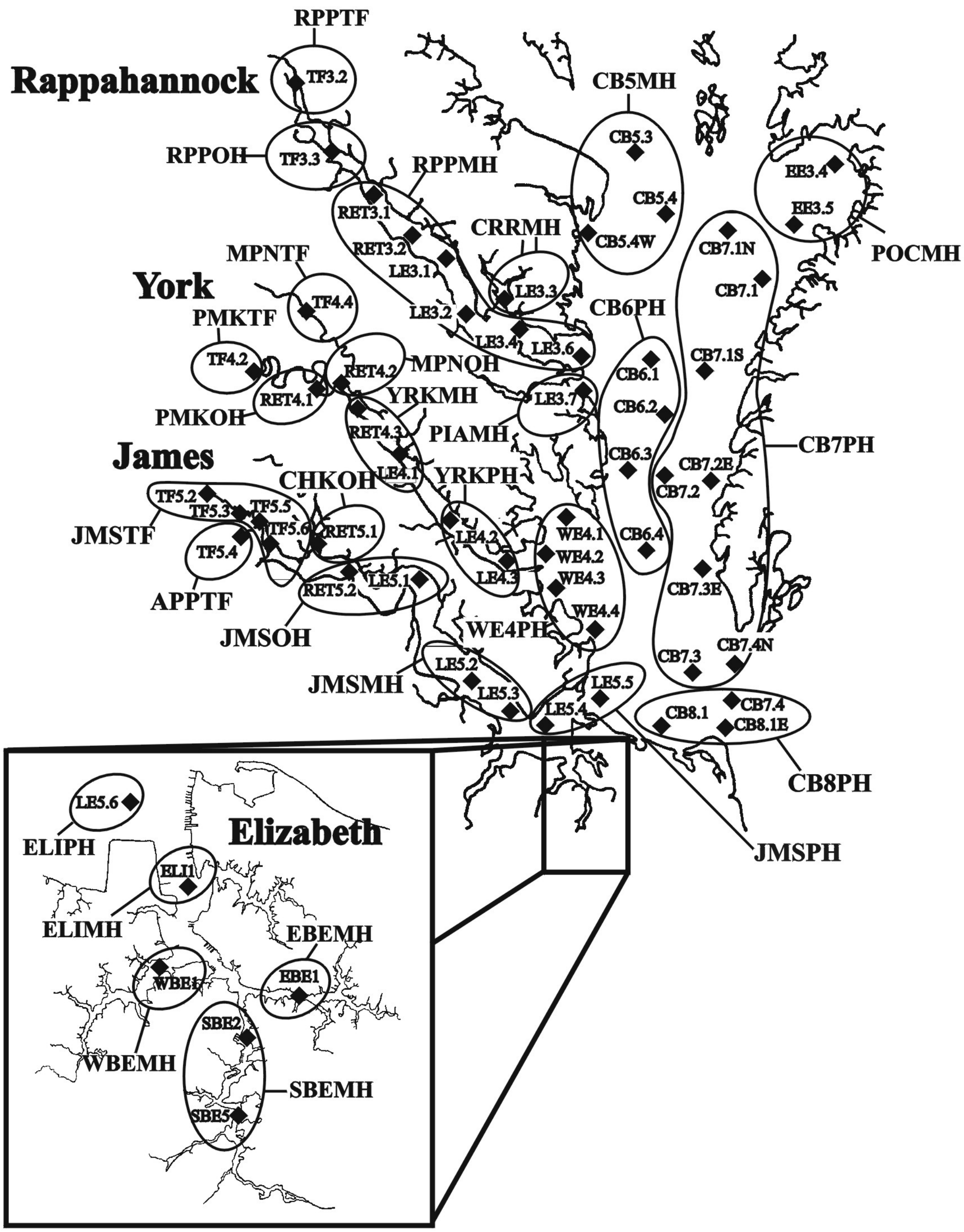


Figure 2-2. Map showing the locations of the water quality monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem used in the statistical analyses. Also shown are ellipses that delineate the Chesapeake Bay Program segmentation scheme.

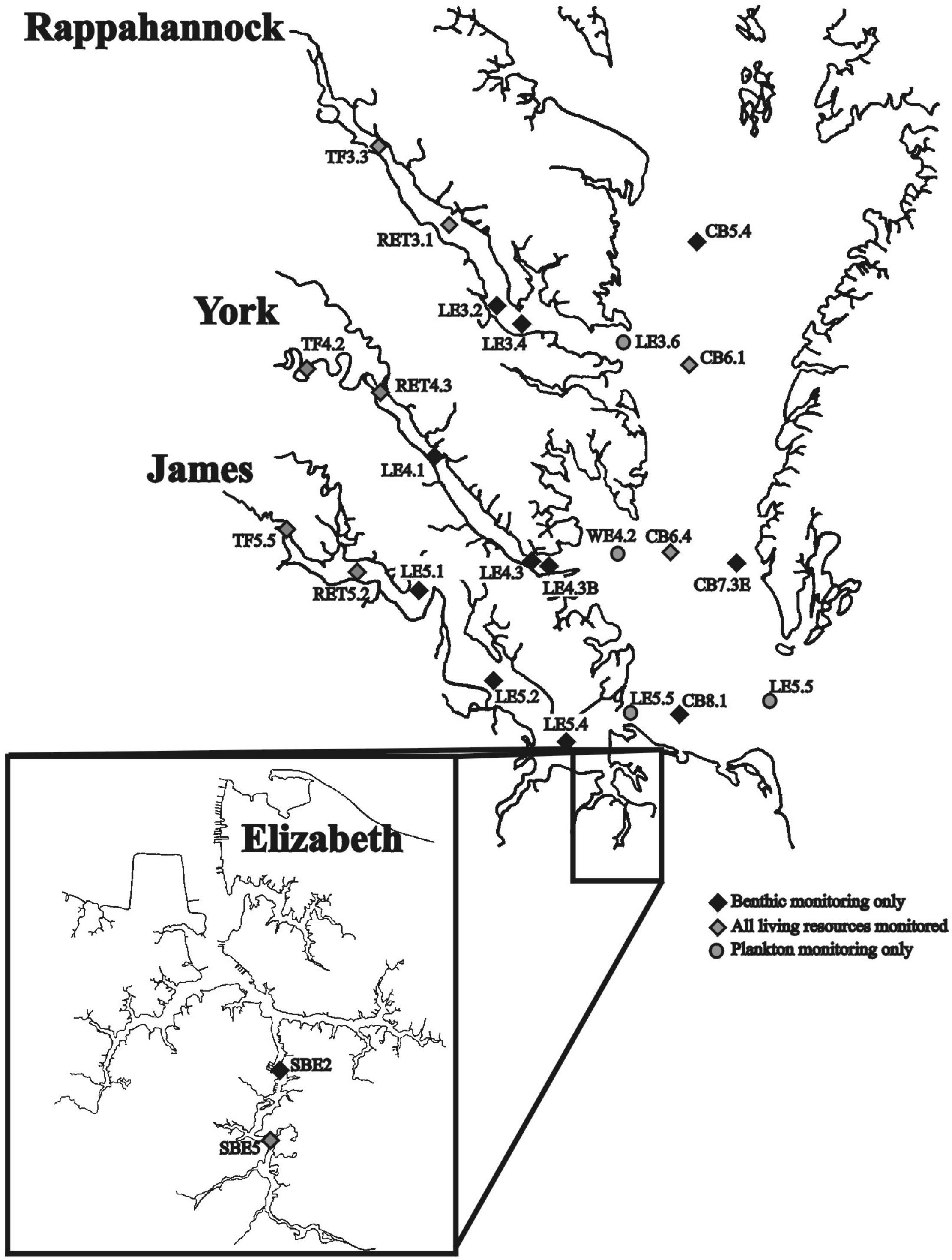


Figure 2-3. Location of living resource monitoring stations in the Virginia tributaries and the Lower Chesapeake Bay Mainstem.

Table 2-1. Definitions of seasonal time periods for status and trend analyses conducted for of the tidal monitoring programs. A "x" indicates the analysis was conducted for the season and parameter group combination while a "-" indicates that no analysis was conducted. *Note that benthic status and trend analyses were conducted on data collected from June 15 through September 30.

		Water Quality			Plankton		Benthos	
Season	Definition	Status	Trend	SAV Goals	Status	Trend	Status	Trend
Annual	Entire year	x	x	-	x	x	-	-
SAV1	March through May and September through November	x	x	x	x	x	-	-
SAV2	April through October	x	x	-	x	x	-	-
Summer1	June through September	x	x	-	x	x	x*	x*
Summer2	July through September	x	x	-	x	x	-	-
Spring1	March through May	x	x	-	x	x	-	-
Spring2	April through June	x	x	-	x	x	-	-
Fall	October through December	-	x	-	x	x	-	-
Winter	January and February	-	x	-	x	x	-	-

Table 2-2. Habitat requirements for growth and survival of SAV (from Batuik et al., 1992; 2000).

Salinity Regime	SAV Growth Season	Light Attenuation Coefficient (Kd)	Percent Light at Leaf	Total Suspended Solids (mg/l)	Chlorophyll *a* (µg/l)	Dissolved Inorganic Nitrogen (mg/l)	Dissolved Inorganic Phosphorus (mg/l)
Tidal Freshwater	Apr.-Oct.	<2	>9	<15	<15	none	<0.02
Oligohaline	Apr.- Oct.	<2	>9	<15	<15	none	<0.02
Mesohaline	Apr.-Oct.	<1.5	>15	<15	<15	<0.15	<0.01
Polyhaline	Mar.-May,	<1.5	>15	<15	<15	<0.15	<0.01

Chapter 3. James River Basin

I. Executive Summary

A. Summary of Basin Characteristics

The James River basin is the largest river basin in Virginia covering 26,422 km^2 or nearly 25% of the Commonwealth's total area. The James River begins in the Allegheny Mountains where it is formed by the confluence of the Jackson and Cowpasture rivers. From its sources, the James River flows 547 km in a southeasterly direction to the fall-line near Richmond and for an additional 180 km to Hampton Roads where it enters Chesapeake Bay. Approximately 71% of the entire basin is forested and an additional 17% of the watershed is covered by agricultural land. All other land use types account for just over 12% of the basin. Approximately 16,600 km of the 44,290 km (38%) of streambanks and shoreline within the watershed have a 30 m minimum riparian forest buffer. The population in the James River basin for 2000 was 2,522,583 people with a population density of 93.4 individuals per km^2. Most of the basin's population is concentrated in approximately 5% of the watershed which consists of residential and industrial land found in the urban areas of Tidewater, Richmond, Petersburg, Lynchburg and Charlottesville.

Total point and non-point source loadings of nitrogen were estimated to be 16,132,907 kg/yr in 2000. Total point and non-point source loadings of phosphorus and sediments were approximately 2,587,742 kg/yr and 1,096,793 metric tons/yr with point sources accounting, respectively in 2000. In 2001, point source loads for total nitrogen and total phosphorus in the James River watershed were approximately 6,974,100 kg/yr and 607,670 kg/yr, respectively. Daily freshwater flow at the fall-line ranged from a minimum of 12.66 m^3/sec to a maximum of 5,635 m^3/sec for the period of January 1, 1985 through December 31, 2002. Grand mean flow at the fall-line was 193.30 m^3/sec. Figures 4-1 to 4-7 provide summary information of basin characteristics of the James River.

B. Summary of Status and Long Term Trends

Figures 3-8 to 3-11 provide summaries of water quality status and trend analyses for the James and Elizabeth rivers. Status of nitrogen parameters was either good or fair in all segments of the James River. Relative status of total phosphorus and dissolved inorganic phosphorus was good and fair in the upper segments of the James River (JMSTF, APPTF, and CHKOH) and poor in the lower segments (JMSOH, JMSMH, JMSPH). Status of nutrients for most of the segments in the Elizabeth River was poor or fair except for some nitrogen parameters in the Western Branch (WBEMH) and the Elizabeth River Mainstem and Mouth (ELIMH and ELIPH). Status of chlorophyll *a* was poor in all segments of the James River except for the Middle and Lower James River (JMSOH and JMSMH) were it was good. Status of total suspended solids was poor or fair in most segments of the James and Elizabeth River. Status of water clarity was fair or poor in most segments of the James and Elizabeth River. Status of bottom dissolved oxygen was good throughout the James River and in most segments of the Elizabeth River, with the exception of the Eastern Branch (EBEMH) and the Southern Branch (SBEMH) which were fair. Most parameters did not meet the SAV habitat requirements in the James River, with the exception of the James River Mouth (JMSPH) which met all of the SAV habitat requirements. In the Elizabeth River the surface dissolved inorganic nitrogen and the surface dissolved inorganic phosphorus did not meet SAV habitat requirements throughout the river. For the non-nutrient parameters in the Elizabeth River (surface chlorophyll *a*, surface total suspended solids and secchi), all segments met the SAV habitat requirements except the Western Branch (WBEMH) which failed in the water clarity measurements of surface total suspended solids and secchi.

Improving trends in surface and bottom dissolved inorganic phosphorus were detected in the Appomattox River (APPTF) and Chickahominy River (CHKOH) and for bottom dissolved inorganic phosphorus for the Upper James River (JMSTF). Degrading trends were detected for surface and bottom dissolved inorganic phosphorus in the Middle James River (JMSOH) and bottom dissolved inorganic phosphorus for the Lower James River (JMSMH). A degrading trend in surface chlorophyll *a* was detected in the Upper James River (JSMTF). Degrading trends were detected in surface total suspended solids in the Chickahominy River (CHKOH) and the James River Mouth (JSMPH). Degrading trends were detected in bottom total suspended solids in the Upper James River (JMSTF), the Chickahominy River (CHKOH) and the Lower James River (JMSMH). Degrading trends in secchi depth were detected in the Upper James River (JMSTF), the Chickahominy River (CHKOH), and the James River Mouth (JSMPH). Improving trends in summer bottom dissolved oxygen were detected in the Appomattox River (APPTF), the Upper James River (JMSTF) and the James River Mouth (JMSPH). Increasing trends in surface and bottom water temperature were detected in the Appomattox River (APPTF) and the Upper James River (JMSTF). Increasing trends in surface and bottom salinity were detected in nearly all segments of the James River with the exception of the James River Mouth (JMSPH) were a decreasing trend in bottom salinity was detected. Improving trends in all nutrients were detected in all segments of the Elizabeth River except the Elizabeth River Mouth (ELIPH). Improving trends in secchi depth were detected in the Western Branch (WBEMH), Southern Branch (SBEMH) and Eastern Branch (EBEMH) of the Elizabeth River. Improving trends in summer bottom dissolved oxygen were detected in all segments of the Elizabeth River. Widespread increasing in surface and bottom water temperature and salinity were also detected in the Elizabeth River.

Figures 3-12 to 3-14 provide summaries of living resources status and trend analyses for the James River. Although, the phytoplankton composition in the James River is represented by favorable dominance and abundance levels of diatoms, chlorophytes, and cryptophytes, there are still signs for concern. For instance, the status of the cyanobacteria is poor throughout the tidal river stations, and they possess degrading trends in both increasing biomass and abundance. Similar unfavorable signs include the poor status of dinoflagellates at two of the three stations, and fair status at the other station. In addition, species diversity status is either poor or fair at these stations. Productivity rate status is poor at TF5.5, with mixed status downstream. Other indices and trends show mixed, or more favorable patterns, as with decreasing autotrophic picoplankton abundance and increasing biomass of diatoms. Should this trend reverse itself, and continued increases in the cyanobacteria and dinoflagellates continue, then there would be broad environmental impacts on trophic relationships in the river.

Status in copepod nauplii abundance was poor at the James River Mouth (JMSPH), fair in the Middle James River (JMSOH), and good in the Upper James River (JMSTF). Status in copepod nauplii abundance was poor in the Southern Branch of the Elizabeth River (SBEMH). Status in rotifer abundance was poor in the Upper James River (JMSTF) and at the James River Mouth (JMSPH) and good in the Middle James River (JMSOH). Improving trends in copepod nauplii abundance and rotifer abundance were detected in the Upper James River (JMSTF) and the Middle James River (JMSOH). Degrading trends in rotifer abundance were detected in the Upper James River (JMSTF) and at the James River Mouth (JMSPH).

Improving trends in the benthic IBI were detected in the Tidal Freshwater James River (JMSTF), the Oligohaline James River (JMSOH) and the Southern Branch of the Elizabeth River. The benthic IBI either met goals or was marginal within the main stem of the James River while status of the benthic IBI within the Elizabeth River was degraded.

C. Summary of Major Issues in the Basin

Two major water quality issue are evident in the main stem of the James River. The first is the apparent widespread problem in water clarity. Although poor relative status occurred in only the Upper James River (JMSTF) and the Appomattox River (APPTF), the SAV habitat requirement for secchi depth was not met in any segments except the James River Mouth (JMSPH). In addition, degrading trends in secchi depth occurred in half of the segments in the James River and were found in not only in the Upper James River (JMSTF) and the Chickahominy River (CHKOH) but also at the James River Mouth (JMSPH). These trends are probably related to the degrading trends in surface chlorophyll *a* and surface and bottom total suspended solids also observed in these segments.

In addition to water clarity, nutrients appear to also be problematic in this tributary especially in the middle and lower reaches of the estuary. Relative status of surface and bottom dissolved inorganic phosphorus was poor in the Middle Rappahannock River (JMSOH) and the Lower Rappahannock River (JMSMH) and the status of surface and bottom total phosphorus was also poor in the Lower Rappahannock River. The SAV habitat criteria for surface dissolved inorganic nitrogen was also not met in these two segments although violations occurred in other segments as well. Finally, degrading trends in surface and bottom dissolved inorganic nitrogen were detected in both of these segments.

In the Elizabeth River, water quality problems are more widespread and primarily due to excessive nutrient concentrations as is evidenced by the widespread poor and fair status of the nitrogen and phosphorus parameters throughout the river. In addition, the SAV habitat criteria for both dissolved inorganic nitrogen and phosphorus were exceeded in every segment of the Elizabeth River. Despite these problems, conditions in the Elizabeth River appear to be improving as was indicated by the improving trends of nearly all nutrient parameters in all segments within the Elizabeth River.

Low freshwater flows in the James River during the last four years may have also have caused or exacerbated water quality problems in the James River. Trends detected in the data collected after the method change suggest that water quality conditions in the James River were improving rather than degrading.

With regard to algal levels, increasing cyanobacterial abundances throughout the river are of particular concern. Degrading trends in both microzooplankton and mesozooplankton bioindicators at the mouth of the river were associated with water clarity and salinity declines. Further consideration should be given to the ecological implications of these zooplankton trends specifically as it might affect stocks of planktivorous feeding fish. Despite a significant improving trend in the B-IBI at one station, the status of the B-IBI within the Southern Branch of the Elizabeth River remains degraded.

II. Management Recommendations

Problems both with respect to water quality and living resources are still evident in the James River, despite improvements in point source nutrient loadings. Problems with nutrients appear to be localized especially in the mesohaline and polyhaline segments of the James River and in the Elizabeth River. These segments are located in or near the largest concentration of urban land in the state of Virginia. This suggests that the environmental problems in these areas may be the result of their proximity to the point sources and urban non-point sources in this population center. Additional point source and non-point source controls will help alleviate these problems. If nutrient concentrations are not limiting in these areas, water clarity may be reduced by a high concentrations of total suspended solids and/or high phytoplankton concentrations caused by existing nutrient levels. Additional point and non-point nutrient controls could also ameliorate water clarity problems within these segments. Problems with water clarity are more widespread in both James and the Elizabeth suggesting a combination of factors such as non-point and point source sediment loadings, or high phytoplankton concentrations may be adversely effecting water clarity.

Problems with phytoplankton communities also tended to be more widespread as exhibited by: 1) the occurrence of long-term degrading trends in cyanobacteria abundance and biomass; 2) the fair to poor status of dinoflagellates, and the poor status of cyanobacteria biomass; and 3) the poor status of the biomass to abundance ratio at all stations in this basin. Problems with SAV habitat requirements also tended to be widespread. All segments except the polyhaline James River had at least one parameter which failed to meet the SAV Habitat Requirements. Within the lower portions of the James River and the segments located in the Elizabeth River, water quality problems are most likely caused by nutrient loadings from point source loadings and urban run-off.

The cause of water quality and living resource problems in the upper segments of the James River and the Appomattox and Chickahominy rivers is unclear. A more concerted effort should be placed on on determining the cause of the water quality and living resource problems in these segments.

III. Overview of Monitoring Results

Figures 3-8 and 3-9 summarize the annual status and trend results for water quality in the James River. Status of surface and bottom total nitrogen and dissolved inorganic nitrogen was either good or fair in all segments of the James River. Status of surface and bottom total phosphorus was good or fair in all segments of the James River except the Lower James River (JMSMH) where it was poor. Status of surface and bottom dissolved inorganic phosphorus was good or fair in all segments of the James River except the Middle James River (JMSOH) and the Lower James River (JMSMH).

Improving trends that were consistent between the pre- and post-method change period were detected in surface and bottom total nitrogen in the Chickahominy River (CHKOH) and in surface total nitrogen in the Middle James River (JMSOH). Improving trends that were consistent between the pre- and post-method change period were detected in surface and bottom dissolved inorganic nitrogen in the Middle James River (JMSOH), in surface dissolved inorganic nitrogen in the Upper James River (JMSTF) and in bottom dissolved inorganic nitrogen in the Appomattox River.

SAV habitat requirements were met for all parameters at the James River Mouth (JMSPH). In the Lower James River (JMSMH) the SAV habitat requirements were met for all parameters except surface dissolved inorganic phosphorus and secchi depth. In the Middle James River (JMSOH), only surface chlorophyll *a* met its respective SAV habitat requirement. In the Upper James River (JMSTF), only surface total suspended solids met its respective SAV habitat requirement. Only surface dissolved inorganic phosphorus met the SAV habitat requirements in the Appomattox River (APPTF) and the Chickahominy River (CHKOH). The SAV habitat requirement for secchi depth was not met in any segment except the James River Mouth (JMSPH).

Improving trends in surface and bottom dissolved inorganic phosphorus that were consistent between the pre- and post-method change periods were detected in the Appomattox River (APPTF) and Chickahominy River (CHKOH) and for bottom dissolved inorganic phosphorus for the Upper James River (JMSTF). Degrading trends that were consistent between the pre- and post method change periods were detected for surface and bottom dissolved inorganic phosphorus in the Middle James River (JMSOH) and bottom dissolved inorganic phosphorus for the Lower James River (JMSMH). A degrading trend in surface chlorophyll *a* was detected in the Upper James River (JSMTF). Degrading trends were detected in surface total suspended solids in the Chickahominy River (CHKOH) and the James River Mouth (JSMPH). Degrading trends were detected in bottom total suspended solids in the Upper James River (JMSTF), the Chickahominy River (CHKOH) and the Lower James River (JMSMH). Degrading trends in secchi depth were detected in the Upper James River (JMSTF), the Chickahominy River (CHKOH), and the James River Mouth (JSMPH). Increasing trends in surface and bottom water temperature were detected in the Appomattox River (APPTF) and the Upper James River (JMSTF). Increasing trends in surface and bottom salinity were detected in nearly all segments of the James River with the exception of the James River Mouth (JMSPH) were a decreasing trend in bottom salinity was detected.

Figures 3-10 and 3-11 summarize the annual status and trend results for water quality in the Elizabeth River. Status of surface and bottom total nitrogen was fair or poor in most segments of the Elizabeth River except at the Elizabeth River Mouth (ELIPH) where status for these parameters was good. Status of surface and bottom dissolved inorganic nitrogen was poor or fair in all segments of the Elizabeth River except the Western Branch (WBEMH) where the status was good. Status of surface and bottom total phosphorus and dissolved inorganic phosphorus was either fair or poor in all segments of the Elizabeth River. Status of surface chlorophyll *a* was poor in the Western Branch (WBEMH) and Elizabeth River Mainstem (ELIMH), fair at the Elizabeth River Mouth (ELIPH) and good in the Southern Branch (SBEMH) and Eastern Branch (EBEMH). Status of surface and bottom total suspended solids and secchi depth was good or fair in all segments of the Elizabeth River except for the Western Branch where status of this parameter was poor. Status of bottom dissolved oxygen was good or fair in all segments of the Elizabeth River. SAV habitat requirements for surface dissolved inorganic nitrogen and surface dissolved inorganic phosphorus were not met in any segment of the Elizabeth River. In contrast, the SAV habitat requirements for surface chlorophyll a, surface total suspended solids and secchi depth were met in all segments except the Western Branch where surface total suspended solids and secchi depth failed to meet the criteria.

Improving trends in all nutrients were detected in all Elizabeth River segments except in bottom total nitrogen in the Southern Branch (SBEMH) and Eastern Branch (EBEMH) and in surface and bottom dissolved inorganic phosphorus at the Elizabeth River Mouth (ELIPH). For surface and bottom dissolved inorganic phosphorus at the Elizabeth River Mouth (ELIPH) significant degrading trends were detected in both the pre- and post-method change periods. Improving trends in bottom dissolved oxygen were detected in all segments in the Elizabeth River. Improving trends in secchi depth were detected in the Western Branch, Southern Branch and Eastern Branch (WBEMH, SBEMH, EBEMH). Increasing trends in water temperature and salinity were detected throughout the Elizabeth River.

Long term trend and status analysis results for living resources are summarized for all stations in James River in Figures 3-12 to 3-13. Long term trends indicate a general pattern of increased phytoplankton abundance in the upper and middle stations, and no significant change at the river mouth. Phytoplankton biomass also had increasing trends at each station, with the biomass status degrading from good to poor downstream. Contributing to these increases are a combination of favorable and unfavorable categories of algae. In general diatoms, chlorophytes, and cryptophytes represent the more favorable components that show increased trends in biomass and favorable status, but these are accompanied by the less favorable increase of cyanobacteria abundance and biomass. Also, less favorable is the poor status associated with the dinoflagellates and cyanobacteria. However, the procaryote to eukaryote ratio shows no significant change, with improvement indicated in the biomass to abundance ratio, while still retaining poor status. Within the river species diversity status was fair to poor, with a general pattern of a decreasing trend in productivity, possibly associated with levels of suspended solids in the system. Of note, are the favorable trends at all the tidal stations of decreasing autotrophic picoplankton abundance, plus its favorable status at these stations. The floral composition within this river goes through a transition from predominantly fresh water species to estuarine flora downstream. Upstream the composition is dominated by diatoms, with chlorophytes and cyanobacteria background species, and dinoflagellates less common. Moving downstream, estuarine diatoms (a different composition), dinoflagellates, chlorophytes, and cyanobacteria replace the fresh water forms. The Elizabeth River flora is most similar to that of the lower Chesapeake Bay. Becoming more abundant in the lower reaches of the James River and various inlets are frequent dinoflagellate blooms.

Status in copepod nauplii abundance was poor at the James River Mouth (JMSPH), fair in the Middle James River (JMSOH), and good in the Upper James River (JMSTF). Status in copepod nauplii abundance was poor in the Southern Branch of the Elizabeth River (SBEMH). Status in rotifer abundance was poor in the Upper James River (JMSTF) and at the James River Mouth (JMSPH) and good in the Middle James River (JMSOH). Improving trends in copepod nauplii abundance and rotifer abundance were detected in the Upper James River (JMSTF) and the Middle James River (JMSOH). Degrading trends in rotifer abundance were detected in the Upper James River (JMSTF) and at the James River Mouth (JMSPH).

Benthic community status in all segments of the James River was good except for station LE5.2 in the Lower James River (JMSMH) where the status was degraded. Improving trends in the B-IBI were detected at station TF5.5 in the Upper James River (JMSTF) and station RET5.2 in the Middle James River (JMSOH). Benthic community status in the Southern Branch (SBEMH) was poor at both station SBE5 and station SBE2. An improving trend in the B-IBI was detected at station SBE5 and was related to improving trends in several metrics measuring community composition including pollution indicative and pollution sensitive species biomass and abundance.

IV. Overview of Basin Characteristics

The James River basin is the largest river basin in Virginia covering 26,422 km^2 or nearly 25% of the Commonwealth's total area. The James River begins in the Allegheny Mountains where it is formed by the confluence of the Jackson and Cowpasture rivers. From its sources, the James River flows 547 km in a southeasterly direction to the fall-line near Richmond and for an additional 180 km to Hampton Roads where it enters Chesapeake Bay.

The population in the James River basin grew from 2,288,366 individuals in 1990 to 2,522,583 individuals in 2000 (Figure 3-1a) with a basin-wide population density of 93.4 individuals per km^2. Most of the basin's population is concentrated in approximately 5% of the watershed which consists of residential and industrial land found in the urban areas of Tidewater, Richmond, Petersburg, Lynchburg and Charlottesville. Population density in the James River Basin ranges from 108.45 individuals per km^2 in the Middle James River (JMSOH) to 894.53 individuals per km^2 in at the James River Mouth in the vicinity of Hampton Roads (Figure 3-1b).

Approximately 71% of the entire basin is forested and an additional 17% of the watershed is covered by agricultural land. All other land use types account for just over 12% of the basin. Approximately 16,600 km of the 44,290 km (38%) of streambanks and shoreline within the watershed has a 30 m minimum riparian forest buffer. In terms of total area, both forested and agricultural land use types were highest in the region around the Upper James River segment (Figure 3-2a), and accounted for 723.5 km^2 and 262.34 km^2 of land, respectively. The percentage of forested land within sub-watersheds of the James River remained relatively stable at 45% or more of the total sub-watershed from the Middle James River to the Appomattox River. However the percentage of forested land decreased to just under 35% in the Lower James River and to less than 10% at the James River Mouth (Figure 3-2b).

Total point and non-point source loadings of nitrogen were estimated to be 16,132,907 kg/yr in 2000. Total point and non-point source loadings of phosphorus and sediments were approximately 2,587,742 kg/yr and 1,096,793 metric tons/yr, respectively in 2000. Point sources account for approximately 6,173,000 kg/yr (38%) of the total nitrogen loadings and 715,768 kg/yr (nearly 28%) of the total phosphorus loadings (Figure 3-3a-b). Agricultural and forested land accounted for 494,418,550 kg/yr (45%) and 390,099,890 (36%) of the total suspended sediment loadings (Figure 3-3c).

Point source loadings of total nitrogen decreased from 11,231,184 kg/yr in 1985 to 6,974,083 kg/yr in 2001 (Figure 3-4a). Point source phosphorus showed a similar improving trend, decreasing from 1,653,887 kg/yr in 1985 to 607,670 kg/yr in 2001 (Figure 3-4b). Point source discharges for both total nitrogen and total phosphorus appear to be concentrated above the fall-line in James River (AFL-JR) and the James River Mouth (JMSPH) (Figure 3-5a-b).

The ratio of impacted (agricultural and urban) to forested land use peaks in the region around the James River Mouth (Figure 3-6). This suggests that the area around this segment would be more likely than other regions in the basin to experience high non-point source loadings of both nutrients and sediments from agricultural and urban land.

Daily freshwater flow at the fall-line ranged from a minimum of 12.66 m^3/sec to a maximum of 5,635 m^3/sec for the period of January 1, 1985 through December 31, 2002. Grand mean flow at the fall-line was 193.30 m^3/sec. There was a significant decreasing trend in freshwater flow at the James River fall-line and annual peaks in monthly mean flow during the last four years appear to be much lower than during previous years (Figure 3-7a). Annual mean flow ranged from approximately 40% to 50% lower than the grand mean flow during the last four years (Figure 3-7b).

V. Detailed Overview of Status and Trends

A. Fall Line

A decreasing trend in flow was detected in the James River at Cartersville. Improving trends in flow adjusted concentrations, flow weighted concentrations, and loadings of total nitrogen were also detected at this station. Improvements in total nitrogen at this station may have been related to improving trends in flow-adjusted concentrations, flow weighted concentrations, and loadings of nitrate-nitrites (filtered) at Cartersville. Improving trends in total phosphorus and dissolved inorganic phosphorus flow adjusted concentrations, flow weighted concentrations, and loadings were detected at Cartersville. Improving trends in flow weighted concentrations and loadings of total suspended solids were also detected at this station (Table 3-1).

A decreasing trend in freshwater flow was detected above the fall-line in the James River at Scottsville. Improving trends in flow weighted concentrations and loadings of ammonia and nitrate-nitrites were detected at this station. Improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of nitrates (whole) were detected at this station. Improving trends in flow adjusted concentrations, flow weighted concentrations and loadings of total phosphorus were also detected (Table 3-1).

A decreasing trend in freshwater flow was detected above the fall-line in the Appomattox River at Matoaca. Improving trends were detected in loadings of total nitrogen and flow adjusted concentrations and loadings of nitrates-nitrites (fixed). Improving trends in loadings of total phosphorus and flow adjusted concentrations, flow weighted concentrations and loadings of dissolved inorganic phosphorus were also detected at this station. A degrading trend in flow-adjusted concentrations of total suspended solids was detected at this station while improving trends in flow weighted concentration and loadings of total suspended solids at this station (Table 3-1).

B. Polyhaline James River (JMSPH - River Mouth)

1. Water quality for living resources

a) Nutrients parameters

Status of all nutrient parameters was good (Table 3-2). There were significant differences in trends detected between the pre- and post-method change period for surface total nitrogen, surface and bottom dissolved inorganic nitrogen, and bottom total phosphorus. For surface total nitrogen, the pre-method change trend was degrading while the post-method change trend was improving. For surface and bottom dissolved inorganic nitrogen, no significant trends were detected in the pre-method change period while significant degrading trends were detected in the post-method change period. For bottom total phosphorus, there was no significant trend in the pre-method change period while there was an improving trend in the post-method change (Table 3-3).

b) Non nutrient parameters

Status of surface chlorophyll *a*, total suspended solids, and secchi depth was either fair or good (Table 3-2). Degrading trends were detected in surface total suspended solids and secchi depth while an improving trend was detected in summer bottom dissolved oxygen. Increasing trends in bottom water temperature and salinity were detected in this segment (Table 3-3).

2. Water quality for SAV

a) SAV habitat requirements

SAV habitat criteria were met for all parameters in this segment (Table 3-4).

b) Nutrient parameter trends

Significant differences in trends were detected between the pre- and post-method change period for surface total nitrogen and surface total phosphorus (Table 3-5). A degrading trends in the pre-method change data for surface total nitrogen was not detected in the post-method change data. A significant degrading trend was detected in surface dissolved inorganic phosphorus that was consistent between the pre- and post-method change period (Table 3-5).

c) Non nutrient parameter trends

An increasing trend in surface water temperature was detected in this segment (Table 3-5).

3. Living resources

This region contained a mixed representation of the phytoplankton, but remained dominated by diatoms. Poor status and degrading trends were identified for cyanobacterial abundance and biomass. Poor status was also associated with total phytoplankton biomass, and biomass to cell abundance ratio. Productivity status was fair. The diatom status was fair but also contained a favorable trend for increased biomass, whereas the dinoflagellate status was good. In contrast, the chlorophyte and autotrophic picoplankton biomass status were good and fair, with a positive trend for the chlorophytes. There were no significant trends associated for the cryptophytes or dinoflagellates (Figure 3-12). This region remains prone to sporadic and common summer and fall blooms of dinoflagellates. Status of both copepod nauplii and rotifer abundance was poor and there was a degrading trend in rotifer abundance in this segment. An increasing trend in polychaeta larval abundance was also detected. (Figure 3-13). The degrading trends may be reflective of degrading trends in total suspended solids or dissolved inorganic phosphorus or perhaps increasing trends in salinity. Benthic community status was good with no trend in the B-IBI at station LE5.4 (Figure 3-14).

C. Mesohaline James River (JMSMH - Lower James)

1. Water quality for living resources

a) Nutrients parameters

Status of all nitrogen parameters was either good or fair while the status of all phosphorus parameters was poor (Table 3-6). A significant degrading trend in bottom dissolved inorganic phosphorus was

detected that was consistent between pre- and post-method change periods. There were significant differences in trends between the pre- and post-method change periods for surface total nitrogen, surface and bottom total phosphorus, and surface dissolved inorganic phosphorus. An improving trend in surface total nitrogen was detected only in the post-method change period.
The degrading trends in surface and bottom total phosphorus and surface dissolved inorganic phosphorus detected in the pre-method change period were not detected in the post-method change period (Table 3-7).

b) Non nutrient parameters

Although the status of bottom total suspended solids was poor, status of the remaining non nutrient parameters was either good or fair (Table 3-6). A degrading trend in bottom total suspended solids was detected along with increasing surface and bottom salinity and increasing water temperature (Table 3-7).

2. Water quality for SAV

a) SAV habitat requirements

Although SAV habitat requirements were met for surface dissolved inorganic nitrogen, surface chlorophyll *a*, and surface total suspended solids, the habitat requirements were not met for surface dissolved inorganic phosphorus and secchi depth (Table 3-8).

b) Nutrient parameter trends

Significant long-term degrading trends were detected in surface total nitrogen and surface dissolved inorganic nitrogen. Significant differences in trends were detected between the pre- and post-method change periods for surface total phosphorus and dissolved inorganic phosphorus. Degrading trends in the pre-method change data for these two parameters were not detected in the post-method change period (Table 3-9).

c) Non nutrient parameter trends

A significant increasing trend in surface salinity was detected in this segment (Table 3-9)

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment. Benthic community status at station LE5.2 was degraded with no trend in the B-IBI (Figure 3-14).

D. Oligohaline James River (JMSOH - Middle James)

1. Water quality for living resources

a) Nutrient parameters

Status of all nitrogen parameters was good. Status of surface and bottom total phosphorus was good and fair, respectively. Status of both surface and bottom dissolved inorganic phosphorus was poor (Table 3-10). Significant improving trends were detected in surface total nitrogen and surface and bottom dissolved inorganic nitrogen that were consistent between the pre- and post-method change periods. Significant degrading trends in surface and bottom dissolved inorganic phosphorus were detected that were consistent between the pre- and post-method change periods. There were significant differences in trends between the pre- and post-method change periods for surface and bottom total phosphorus. For surface total phosphorus, the pre-method change trend was degrading but the post method change trend was not significant. For bottom total phosphorus, the pre-method change trend was degrading but the post-method change trend was improving (Table 3-11).

b) Non nutrient parameters

Status of all non nutrient parameters was good except bottom total suspended solids for which the status was fair (Table 3-10). Improving trends in surface total suspended solids and secchi depth were detected. Increasing trends in surface and bottom salinity were also detected in this segment (Table 3-11).

2. Water quality for SAV

a) SAV habitat criteria

Although the SAV habitat requirement for surface chlorophyll *a* was met, all other parameters failed to meet their respective criteria (Table 3-12).

b) Nutrient parameter trends

A significant degrading trend in surface dissolved inorganic phosphorus was detected that was consistent between the pre- and post-method change periods. Although a significant trend in surface total phosphorus was detected in the pre-method change data, this trend was not detected in the post-method change data (Table 3-13).

c) Non nutrient parameter trends

An increasing trend in salinity was detected in this segment (Table 3-13).

3. Living resources

This region was dominated by diatoms, with diatoms, chlorophytes, and algal productivity having favorable status and trends, with cryptophytes also with a favorable trend of increased biomass. There were increasing trends associated with phytoplankton abundance and biomass, and the biomass to cell abundance ratio. However, the status was poor for the biomass to cell abundance ratio, with species diversity status poor. Poor status was also associated with dinoflagellate biomass, and cyanobacteria abundance and biomass. There were degrading trends in cyanobacteria abundance. The significance of these cyanobacteria and dinoflagellate trends will depend upon their duration and their potential influence on the trophic relationships in this region (Figure 3-12). The status of the major indicators of microzooplankton was mixed with poor rotifer abundance and good copepod nauplii abundance and there was a significant improving trend in rotifer abundance in this segment. The improving trend in rotifer abundance may reflect the improving trends in water quality detected in this segment (Figure 3-13). Benthic community status was good with an improving trend B-IBI at station RET5.2 and good at station LE5.1 with no trend (Figure 3-14).

E. Tidal Fresh James River (JMSTF - Upper James)

1. Water quality for living resources

a) Nutrient parameters

Status of all nutrient parameters was either good or fair in this segment (Table 3-14). Significant Improving trends in surface dissolved inorganic nitrogen and bottom dissolved inorganic phosphorus were detected that were consistent between the pre- and post-method change periods. There were significant differences in trends between the pre- and post-method periods for surface and bottom total nitrogen and total phosphorus as well as bottom dissolved inorganic nitrogen and surface dissolved inorganic phosphorus. For all of these parameters, a significant improving trend was detected in the pre-method change period which was not significant in the post-method change period (Table 3-15).

b) Non nutrient parameters

Status of surface chlorophyll *a*, surface and bottom total suspended solids and secchi depth was poor. However, status of bottom dissolved oxygen was good (Table 3-14). Degrading trends in surface chlorophyll *a*, bottom total suspended solids, and secchi depth were detected. Increasing trends in surface and bottom water temperature and salinity were also detected in this segment (Table 3-15).

2. Water quality for SAV

a) SAV habitat requirements

Although the SAV habitat requirement was met for total suspended solids, all other parameters failed to meet their respective criteria (Table 3-16).

b) Nutrient parameters

An improving trend was detected in surface dissolved inorganic nitrogen that was consistent between the pre- and post-method change periods (Table 3-17). Although significant improving trends in surface total nitrogen, surface total phosphorus and surface dissolved inorganic phosphorus were detected in the pre-method change data, these trends were not detected in the post-method change data (Table 3-17).

c) Non nutrient parameters

Degrading trends in surface chlorophyll *a* and secchi depth were detected in this segment along with increasing trends in surface water temperature and surface salinity (Table 3-17).

3. Living resources

There were numerous signs of poor status among the phytoplankton indicators along with improving trends. The status of the biomass to cell concentration ratio and species diversity was poor, but their trends were positive. The status of algal productivity, and dinoflagellate biomass were both poor, with no significant trends. Favorable status was associated with total biomass, and the biomass of diatoms, chlorophytes, and cryptophytes, in addition to showing positive trends in biomass. In general, total phytoplankton abundance and biomass were increasing. Of concern is that the cyanobacteria biomass and abundance status are poor, with degrading trends for both cyanobacteria biomass and abundance (Figure 3-12). With respect to microzooplankton community status and trends were mixed with good status for copepod nauplii abundance and poor for rotifer abundance. In addition, an improving trend was detected in copepod nauplii abundance and a degrading trend was detected in rotifer abundance. Increasing trends in total microzooplankton biomass and oligotrich abundance were also detected in this segment (Figure 3-13). Benthic community status was good with a strongly improving trend in the B-IBI and most of the benthic metrics of the B-IBI (Figure 3-14).

F. Tidal Fresh Appomattox (APPTF - Appomattox)

1. Water quality for living resources

a) Nutrient parameters

Status of all nutrient parameters was either good or fair at this segment (Table 3-18). Significant improving trends in bottom dissolved inorganic nitrogen and surface and bottom dissolved inorganic phosphorus were detected that were consistent between the pre- and post-method change periods. A significant degrading trend in bottom total phosphorus was detected that was consistent between the pre- and post-method change periods. A significant degrading trend in surface total nitrogen was detected only in the post-method change period (Table 3-19).

b) Non nutrient parameters

Status of all non nutrient parameters was poor except for bottom dissolved oxygen for which the status was good (Table 3-18). Increasing trends in surface and bottom salinity were detected in this segment (Table 3-19).

2. Water quality for SAV

a) SAV habitat requirements

All parameters except surface dissolved inorganic phosphorus failed to meet the SAV habitat requirements (Table 3-20).

b) Nutrient parameters

A significant degrading trend in surface total nitrogen and a significant improving trend in surface dissolved inorganic nitrogen were detected only in the post-method change data (Table (4-21).

c) Non nutrient parameters

Significant increasing trends were detected in surface water temperature and surface salinity (Table 3-21).

3. Living resources

Living resource monitoring is not conducted within this segment.

G. Oligohaline Chickahominy River (CHKOH - Chickahominy)

1. Water quality for living resources

a) Nutrient parameters

Status of all nutrient parameters was good (Table 3-22). Significant improving trends in surface and bottom total nitrogen and surface and bottom dissolved inorganic phosphorus were detected that were consistent between the pre- and post-method change periods (Table 3-23).

b) Non nutrient parameters

Status of all non nutrient parameters was good except for surface chlorophyll *a* for which the status was poor (Table 3-22). Degrading trends in surface and bottom total suspended solids and secchi depth were detected along with increasing trends in surface and bottom salinity (Table 3-23).

2. Water quality for SAV

a) SAV habitat requirements

All parameters except surface dissolved inorganic phosphorus failed to meet the SAV habitat requirements (Table 3-24).

b) Nutrient parameters

An improving trend was detected in surface total nitrogen that was consistent between the pre- and post-method period in this segment (Table 3-25).

c) Non nutrient parameters

Degrading trends in surface total suspended solids and secchi depth were detected in this segment along with an increasing trend in surface salinity (Table 3-25).

3. Living resources

Living resource monitoring is not conducted within this segment.

H. Polyhaline Elizabeth River (ELIPH - River Mouth)

1. Water quality for living resources

a) Nutrient parameters

Status of total nitrogen was good, and the status of dissolved inorganic nitrogen was fair. The status of the phosphorus parameters was fair, except for bottom dissolved inorganic phosphorus for which it was poor (Table 3-26). Significant improving trends were detected in surface and bottom dissolved inorganic phosphorus that were consistent between the pre- and post-method change periods. There was a significant difference in trends between the pre- and post-method change periods for surface total phosphorus. A degrading trend was detected in the pre-method change period while no significant trend was detected in the post-method period (Table 3-27).

b) Non nutrient parameters

Status in surface chlorophyll a was fair while status in surface and bottom total suspended solids was fair and good, respectively. Status of secchi depth was poor while the status of bottom dissolved oxygen was good (Table 3-26). An improving trend in summer bottom dissolved oxygen was detected and increasing trends were detected in surface and bottom salinity and surface water temperature were detected in this segment (Table 3-27).

2. Water quality for SAV

a) SAV habitat requirements

Although surface chlorophyll *a*, surface total suspended solids and secchi depth met the SAV habitat requirements, surface dissolved inorganic nitrogen and dissolved inorganic phosphorus failed to meet their respective criteria (Table 3-28).

b) Nutrient parameters

Significant degrading trends in surface dissolved inorganic nitrogen and surface dissolved inorganic phosphorus were detected that were consistent between the pre- and post-method change period in this segment. A significant degrading trend was detected in surface total phosphorus only during the pre-method change period (Table 3-29).

c) Non nutrient parameters

An increasing trend in surface salinity was detected in this segment (Table 3-29).

3. Living resources

Living resource monitoring is not conducted within this segment.

I. Mesohaline Elizabeth River (ELIMH - River Mainstem)

1. Water quality for living resources

a) Nutrient parameters

Status was good for bottom total nitrogen, and fair for surface total nitrogen and surface and bottom dissolved inorganic nitrogen. Status for total phosphorus was fair, and for dissolved inorganic phosphorus the status was poor (Table 3-30). Improving trends were detected in all nutrient parameters in this segment except bottom total nitrogen (Table 3-31).

b) Non nutrient parameters

Status of surface chlorophyll *a* was poor. Status of surface and bottom total suspended solids and secchi depth was fair. Status of bottom dissolved oxygen was good (Table 3-30). An improving trend was detected in bottom dissolved oxygen along with increasing trends in surface and bottom water temperature and surface salinity (Table 3-31).

2. Water quality for SAV

a) SAV habitat requirements

Although the SAV habitat requirements for surface chlorophyll *a*, surface total suspended solids and secchi depth were met, both surface dissolved inorganic nitrogen and surface dissolved inorganic phosphorus failed to meet their respective criteria (Table 3-32).

b) Nutrient parameters

An improving trend in surface dissolved inorganic nitrogen was detected in this segment (Table 3-33).

c) Non nutrient parameters

Increasing trends in surface water temperature and surface salinity were detected in this segment (Table 3-33).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

J. Western Branch of the Elizabeth River (WBEMH - Western Branch)

1. Water quality for living resources

a) Nutrient parameters

Status was good for bottom total nitrogen and surface dissolved inorganic nitrogen, and fair for surface total nitrogen and bottom dissolved inorganic nitrogen. Status for phosphorus parameters was poor except for surface dissolved inorganic phosphorus for which the status was fair (Table 3-34). Improving trends were detected in all nutrient parameters in this segment (Table 3-35).

b) Non nutrient parameters

Status of surface chlorophyll a, surface and bottom total suspended solids and secchi depth was poor while status of bottom dissolved oxygen was good (Table 3-34). Improving trends were detected in surface chlorophyll *a*, secchi depth and bottom dissolved oxygen and increasing trends were detected in surface salinity and surface and bottom water temperature (Table 3-35).

2. Water quality for SAV

a) SAV habitat requirements

All parameters except surface chlorophyll *a*, failed to meet the SAV habitat requirements (Table 3-36).

b) Nutrient parameters

Improving trends were detected in surface total nitrogen, surface total phosphorus and dissolved inorganic phosphorus (Table 3-37).

c) Non nutrient parameters

An increasing trend in surface salinity was detected in this segment (Table 3-37).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.

K. Southern Branch of the Elizabeth River (SBEMH - Southern Branch)

1. Water quality for living resources

a) Nutrient parameters

Status of all nitrogen and phosphorus nutrients was poor, except for bottom total phosphorus for which the status was fair (Table 3-38). Improving trends were detected in all of these parameters except for bottom total nitrogen (Table 3-39).

b) Non nutrient parameters

Status of all non nutrient parameters was good, except for bottom dissolved oxygen for which the status was fair (Table 3-38). Improving trends were detected in all non nutrient water quality indicators except surface chlorophyll *a*. Increasing trends were detected in surface and bottom water temperature and surface salinity (Table 3-39).

2. Water quality for SAV

a) SAV habitat requirements

SAV habitat requirements were met for surface chlorophyll *a*, surface total suspended solids and secchi depth; however, both surface dissolved inorganic nitrogen and surface of dissolved inorganic phosphorus failed to meet their respective criteria (Table 3-40).

b) Nutrient parameters

Improving trends were detected in all nutrient parameters in this segment (Table 3-41).

c) Non nutrient parameters

An improving trend in secchi depth was detected in this segment along with increasing trends in surface water temperature and surface salinity (Table 3-41).

3. Living resources

This is one of the highly polluted rivers in Virginia with a phytoplankton populations very similar to the lower Chesapeake Bay, with estuarine diatoms the dominant flora. The status for the total phytoplankton biomass and the biomass to cell abundance ratio is poor. No significant changes were present for the dinoflagellates. Cyanobacteria abundance and biomass status is poor with degrading trends in cyanobacteria biomass and abundance. Total phytoplankton biomass and abundance trends are increasing, with the status of diatoms fair along with an improving trend in biomass. Favorable status is present for the chlorophytes, autotrophic picoplankton and productivity. Although there are several positive signs of improvement, the phytoplankton populations remain under conditions of stress (Figure 3-12). Status of copepod nauplii abundance was poor while status of rotifer abundance was good. Decreasing trends were detected in total microzooplankton abundance and biomass, oligotrich abundance, tintinnid abundance, and polychaeta larval abundance (Figure 3-13). Benthic community status was degraded with an improving trend in the B-IBI at station SBE5. The improving trend in the B-IBI was the result of trends in nearly all metrics measuring the health of benthic community composition. Although the B-IBI shows no significant trend at SBE2, many of the metrics indicate improvement (Figure 3-14).

L. Eastern Branch of the Elizabeth River (EBEMH - Eastern Branch)

<u>1. Water quality for living resources</u>

a) Nutrient parameters

Status of all nitrogen and phosphorus parameters was either fair or poor (Table 3-42). Improving trends were detected in all nitrogen and phosphorus parameters (Table 3-43).

b) Non nutrient parameters

Status of surface chlorophyll *a* and bottom total suspended solids was good. Status of surface total suspended solids, secchi, and bottom dissolved oxygen was fair (Table 3-42). Improving trends were detected in secchi depth and summer bottom dissolved oxygen. Increasing trends were detected in surface and bottom water temperature and salinity (Table 3-43).

<u>2. Water quality for SAV</u>

a) SAV habitat requirements

Although surface dissolved inorganic nitrogen and phosphorus failed to meet the SAV habitat requirements, surface chlorophyll a, surface total suspended solids and secchi depth met their respective requirements (Table 3-44).

b) Nutrient parameters

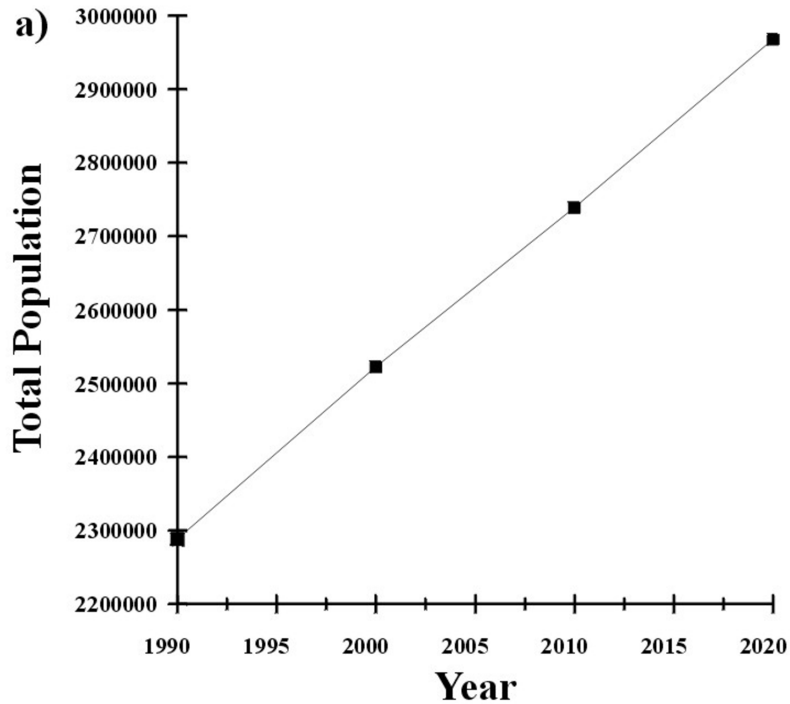
Improving trends were detected in surface dissolved inorganic nitrogen and surface total phosphorus (Table 3-45).

c) Non nutrient parameters

An increasing trend in surface salinity was detected in this segment (Table 3-45).

3. Living resources

Phytoplankton and zooplankton monitoring is not conducted within this segment.



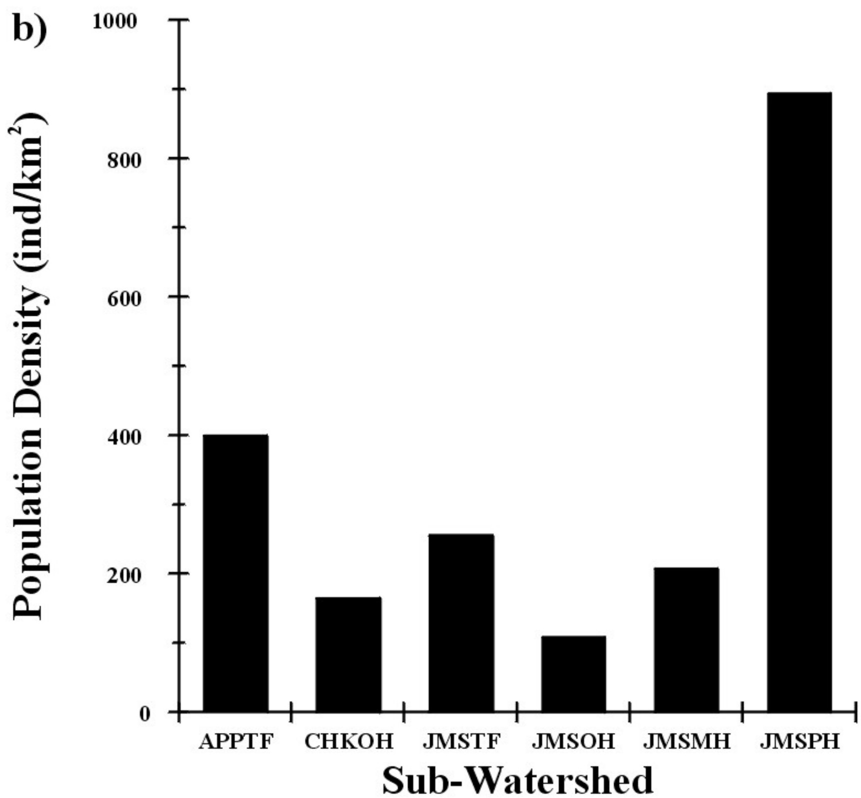


Figure 3-1. Patterns in a) total and projected total watershed population over time and b) population density between sub-watersheds within the James River basin for the year 2000.

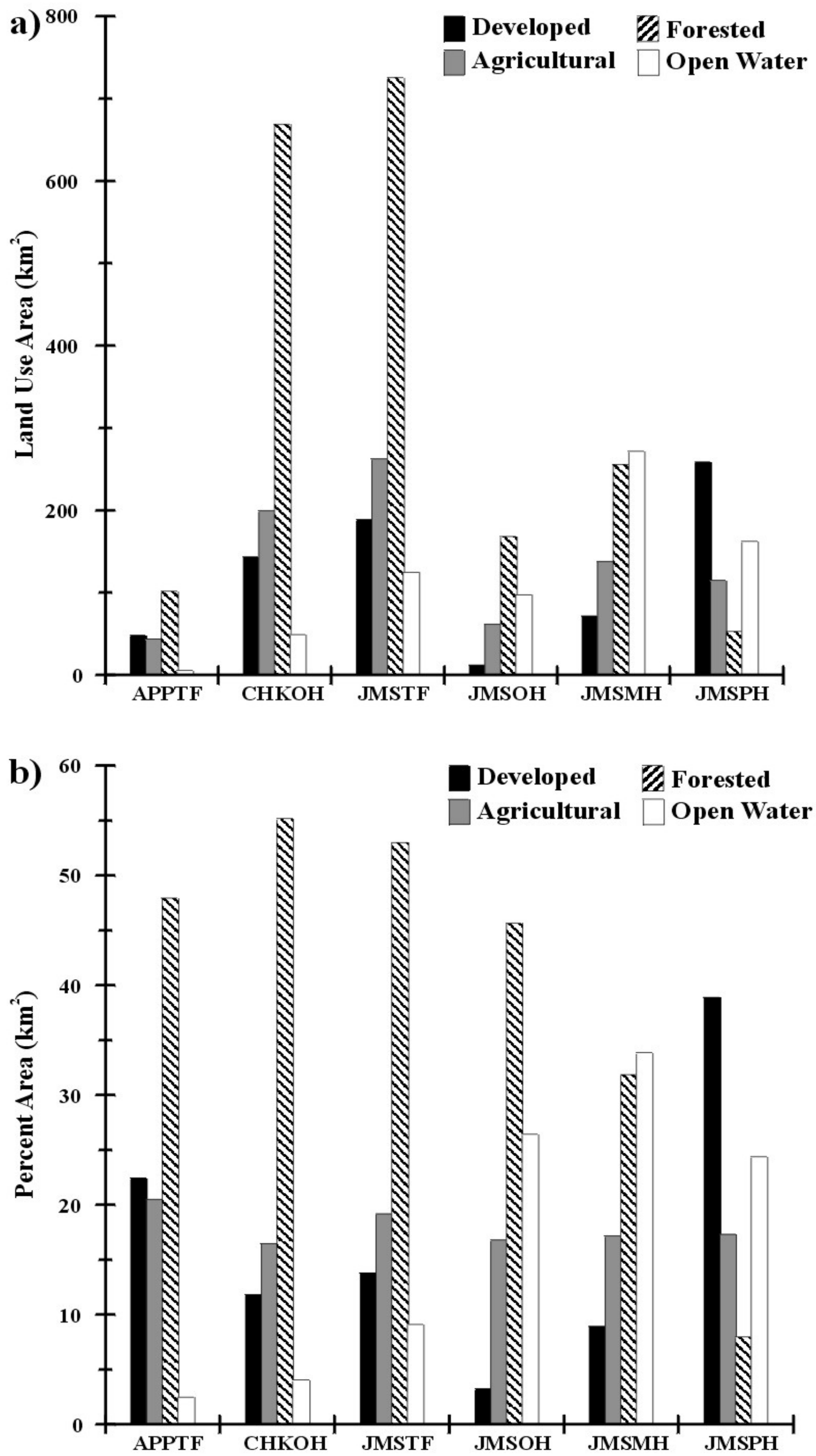


Figure 3-2. Differences in a) total area and b) percentages of land-use types between sub-watersheds of the James River for 1999. Data presented were provided by the USEPA, Chesapeake Bay Program Office.

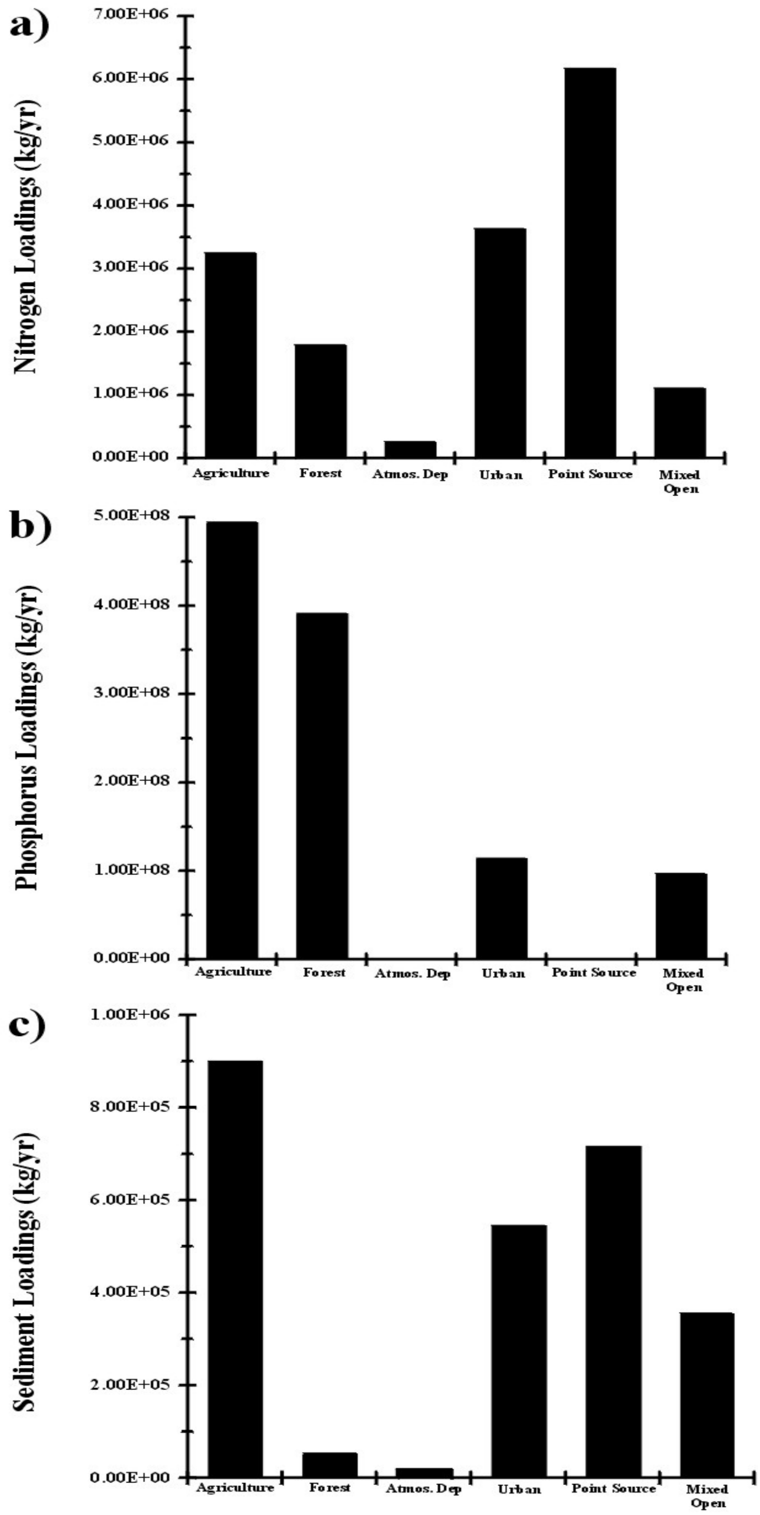


Figure 3-3. Non-point source loadings of a) total nitrogen, b) total phosphorus, and c) sediments by source for the James River in 2000. Data generated using the USEPA Chesapeake Bay Watershed Model.

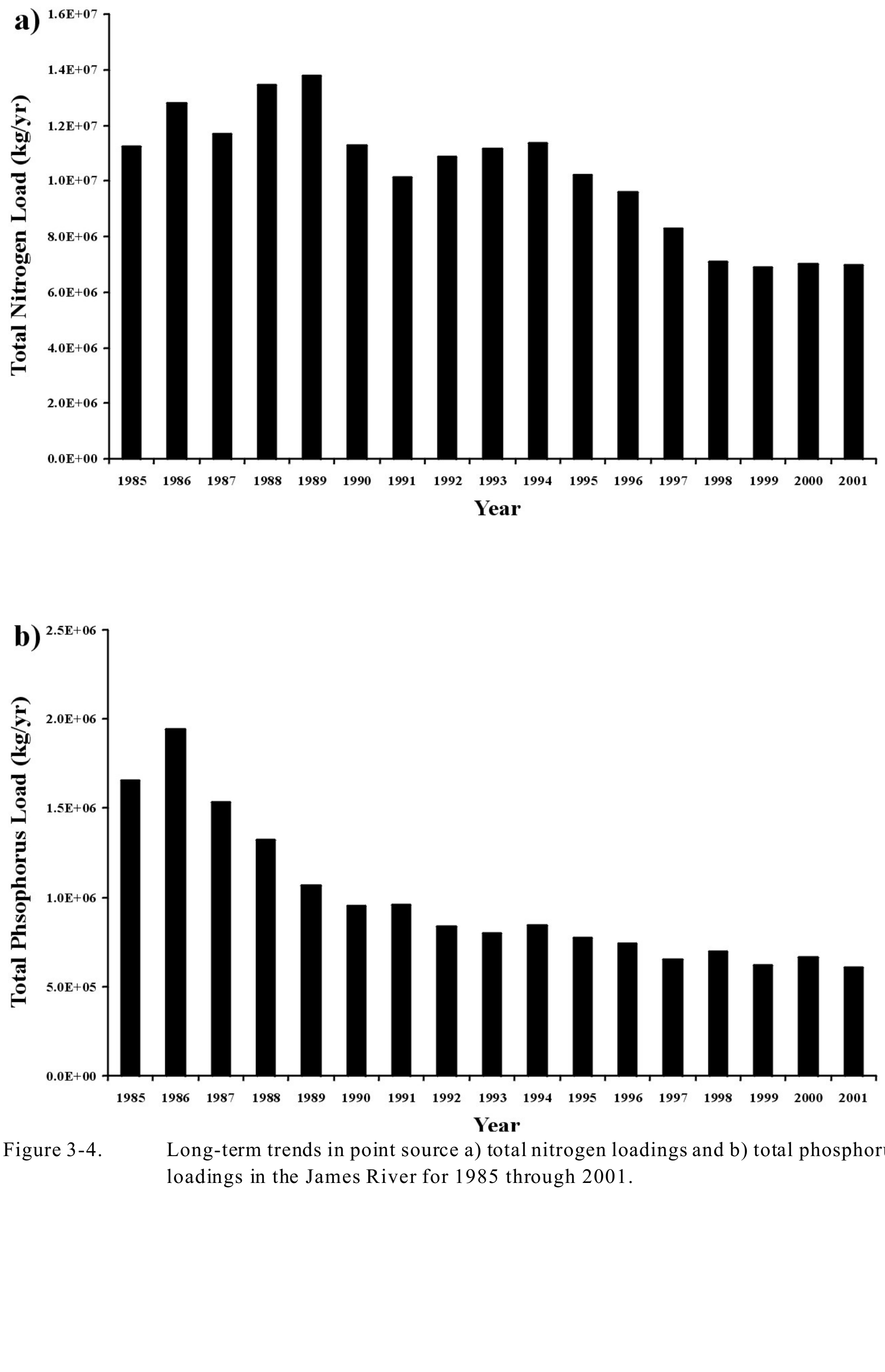


Figure 3-4. Long-term trends in point source a) total nitrogen loadings and b) total phosphorus loadings in the James River for 1985 through 2001.

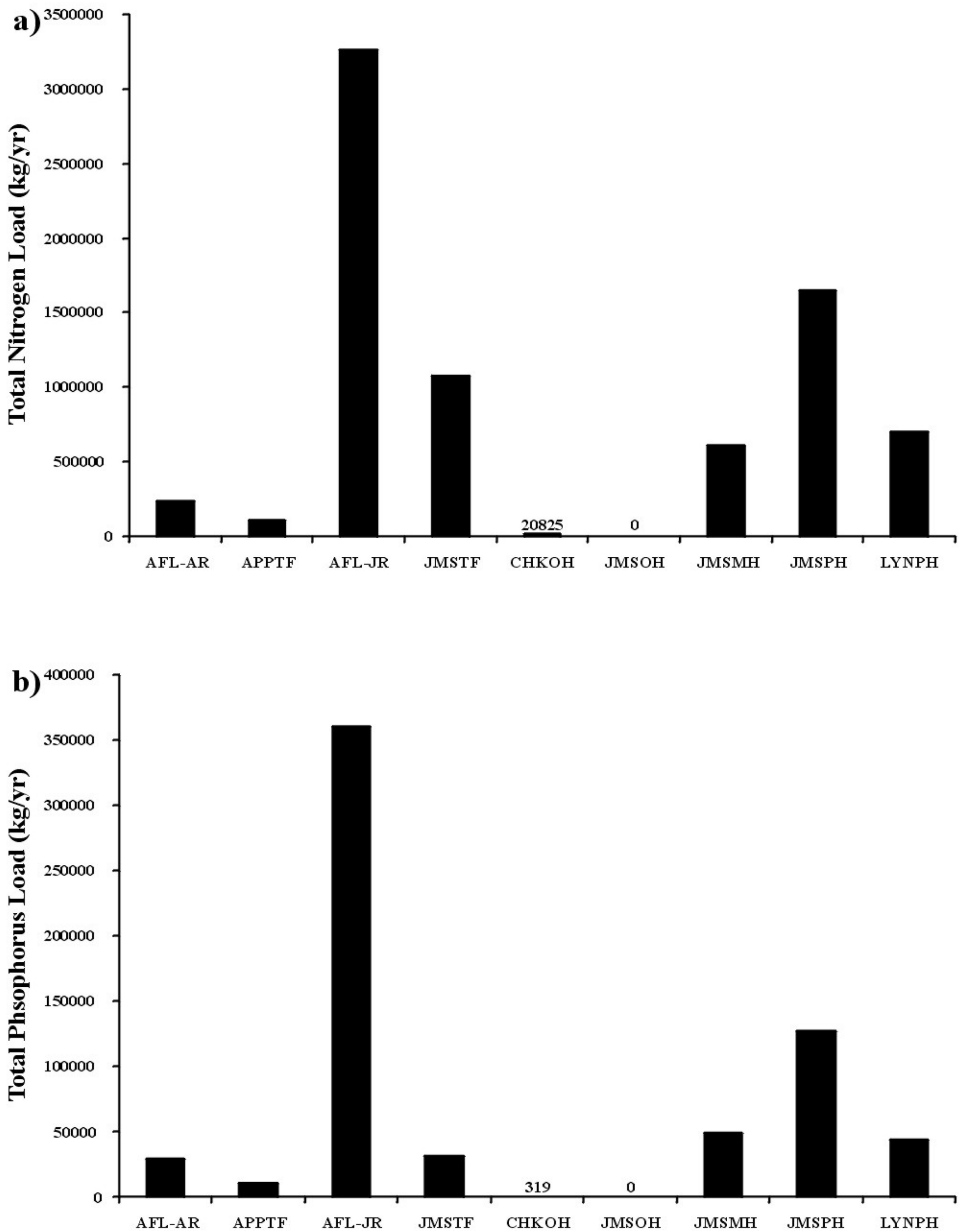


Figure 3-5. Spatial patterns in point source a) total nitrogen and b) total phosphorus loadings in the James River by sub-watershed for 2001. Additional segments are as follows: AFL-AR=Above the Fall-line in the Appomattox River, APPTF=Appomattox River, AFL-JR=Above the Fall-line in the James River, LYNPH=Lynnhaven Bay.

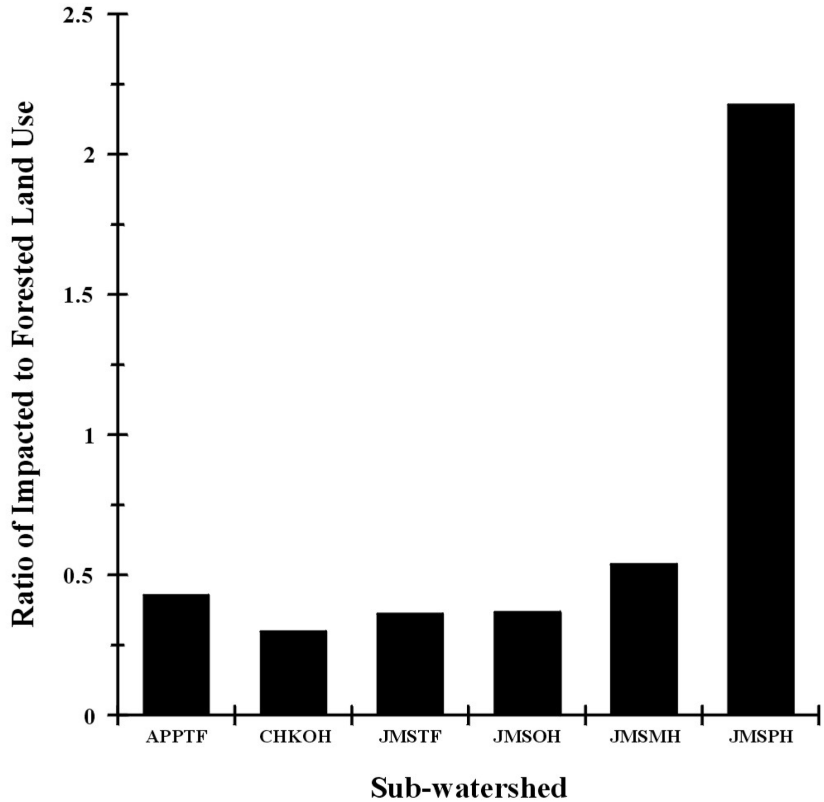


Figure 3-6. Spatial patterns in the ratio of impacted (agricultural and urban land) use to forested land use between sub-watersheds of the James River basin in 2000.

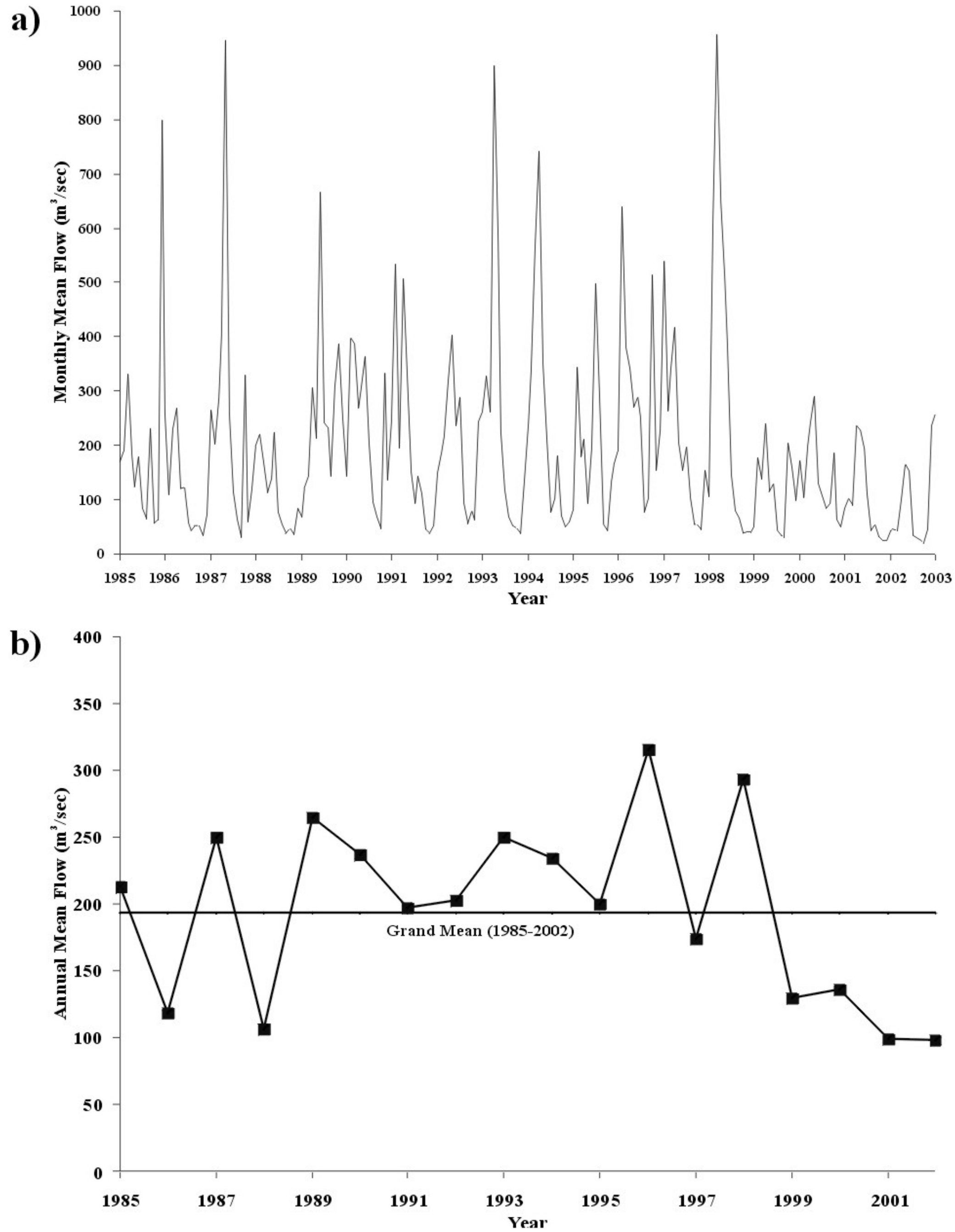
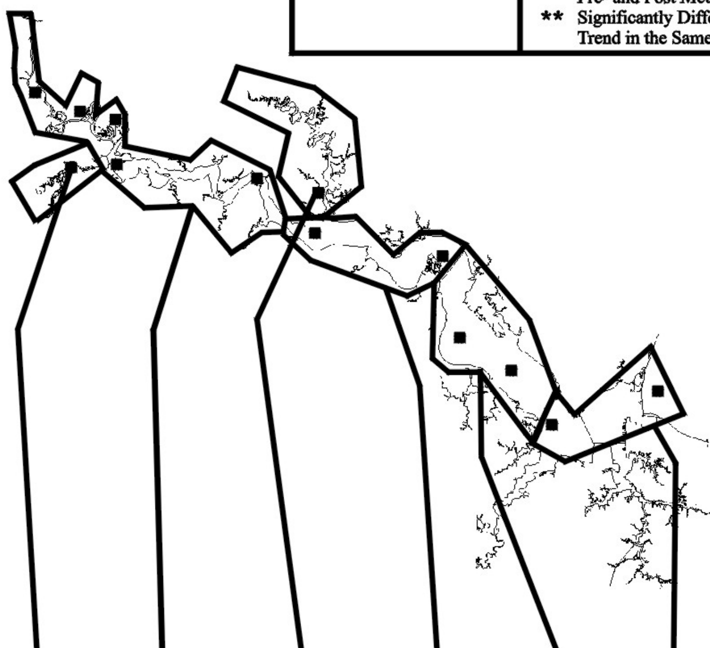


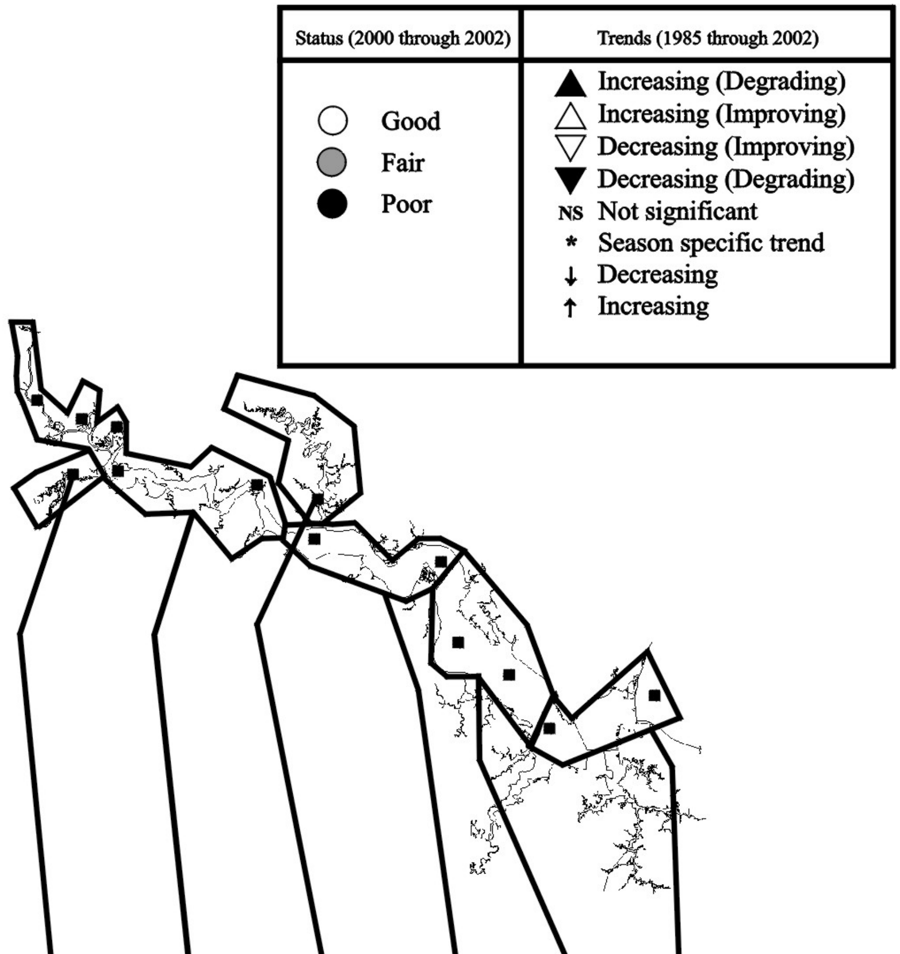
Figure 3-7. Plot of a) monthly mean and b) annual mean freshwater flow at the James River fall-line for the period of 1985 through 2002.

Status (2000 through 2002)	Trends (1985 through 2002)
○ Good	△ Increasing (Improving)
◍ Fair	▲ Increasing (Degrading)
● Poor	▽ Decreasing (Improving)
	▼ Decreasing (Degrading)
	NS Not significant
	* Pre- and Post Method Change Trends Not Significantly Different
	** Pre- and Post Method Change Significantly Different With Trend in the Same Direction



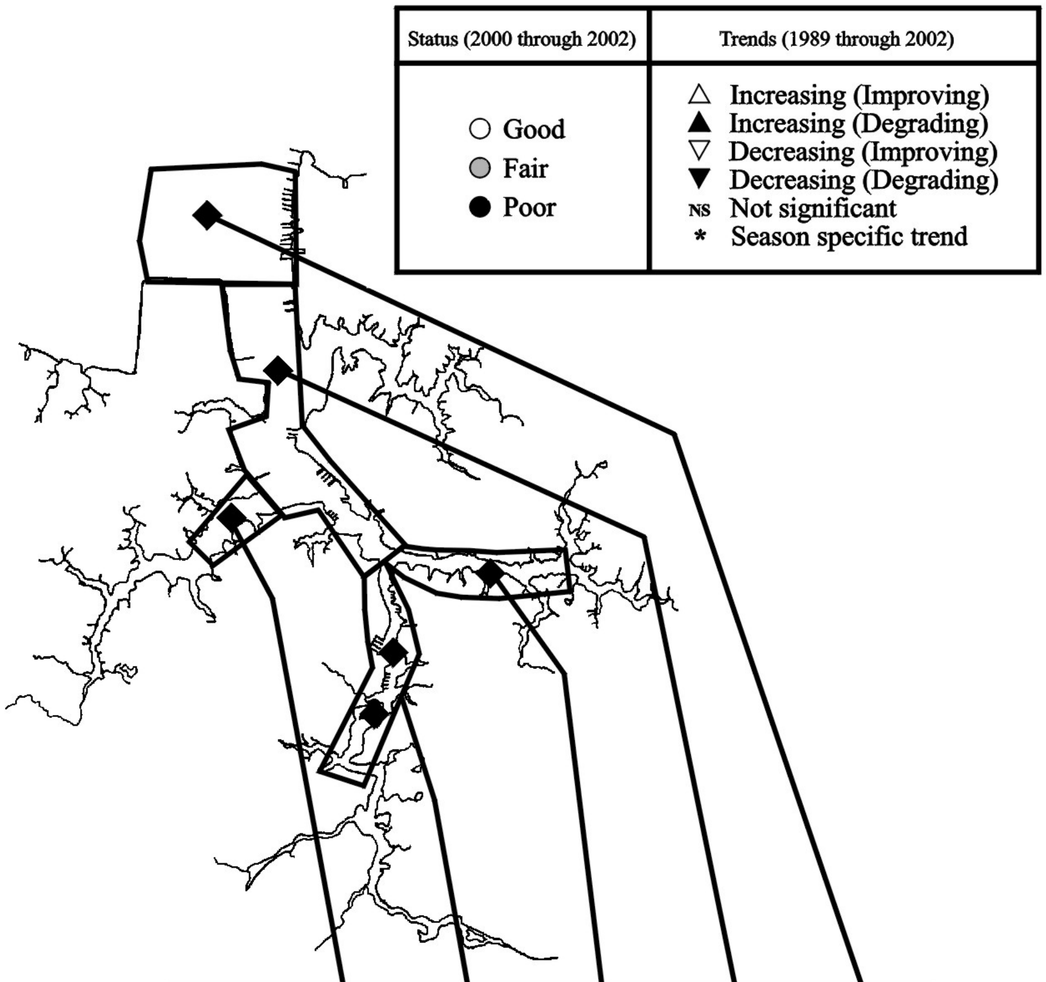
Parameter	Appomatox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
STN	◍ NS▲	○ ▽NS	○ ▽*	○ ▽*	○ NS ▽	○ ▲▽
BTN	○ NS**	○ ▽NS	○ ▽*	○ NS▽	○ NS**	○ NS**
SDIN	○ NS*	◍ ▽*	○ NS *	○ ▽*	◍ NS**	○ NS ▽
BDIN	○ ▽*	○ ▽NS	○ NS *	○ ▽*	○ NS**	○ NS ▽
STP	◍ NS *	○ ▽NS	○ NS**	○▲NS	●▲ NS	○ NS**
BTP	◍ ▲*	◍ ▽NS	○ NS *	◍▲▽	●▲ NS	○ NS ▽
SDIP	○ ▽*	◍ ▽NS	○ ▽*	● ▲*	●▲ NS	○ NS*
BDIP	○ ▽*	◍ ▽*	○ ▽*	● ▲*	● ▲*	○ NS*

Figure 3-8. Map of the James River basin showing summaries of the status and trend analyses for each segment for the period of 1985 through 2002. Abbreviations for each parameter are: TN=total nitrogen, DIN=dissolved inorganic nitrogen, TP=total phosphorus, DIP=dissolved inorganic phosphorus. The prefixes S and B refer to surfaceand bottom measurements, respectively. The presence of two trend symbols indicates a significant difference between pre- and post-method change trends. For such cases, the first symbol represents the pre-method change result while the second symbol is the post method change result.



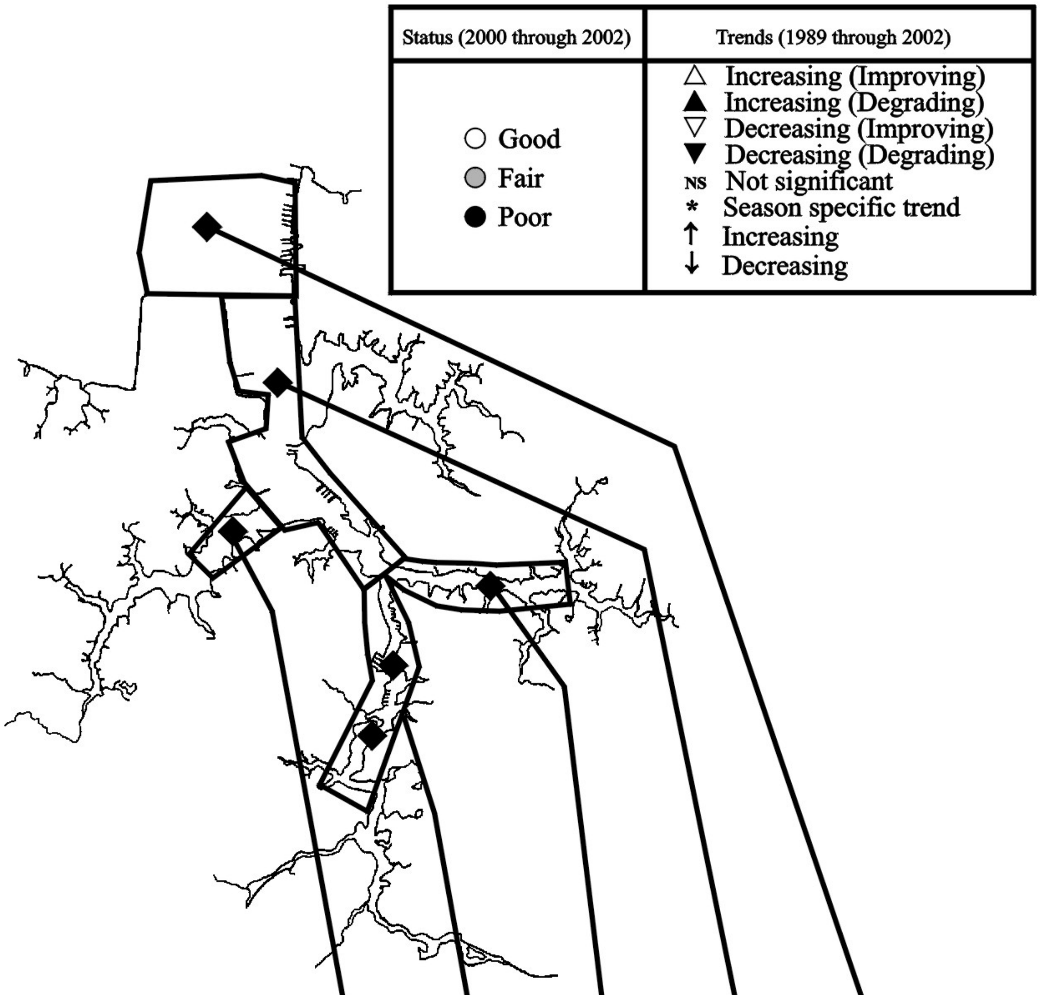
Parameter	Appomattox	Upper James	Chickahominy	Middle James	Lower James	River Mouth
SCHLA	● NS	● ▲	● NS	○ NS	○ NS	○ NS
STSS	● NS	● NS	○ ▲	○ ▽	◍ NS	◍ ▲
BTSS	● NS	● ▲	○ ▲	◍ NS	● ▼	○ NS
SECCHI	● NS	● ▼	○ ▼	○ △	◍ NS	◍ ▼
BDO	○ △	○ △	○ NS	○ NS	○ NS	○ △
SWTEMP	↑	↑	NS	NS	NS	NS
BWTEMP	↑	↑	NS	NS	NS	↑
SSALIN	↑	↑	↑	↑	↑	NS
BSALIN	↑	↑	↑	↑	↑	↓

Figure 3-9. Map of the James River basin showing summaries of the status and trend analyses for each segment for the period of 1985 through 2002. Abbreviations for each parameter are: CHLA=chlorophyll *a*, TSS=total suspended solids, SECCHI=secchi depth, DO=dissolved oxygen, WTEMP=water temperature, SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



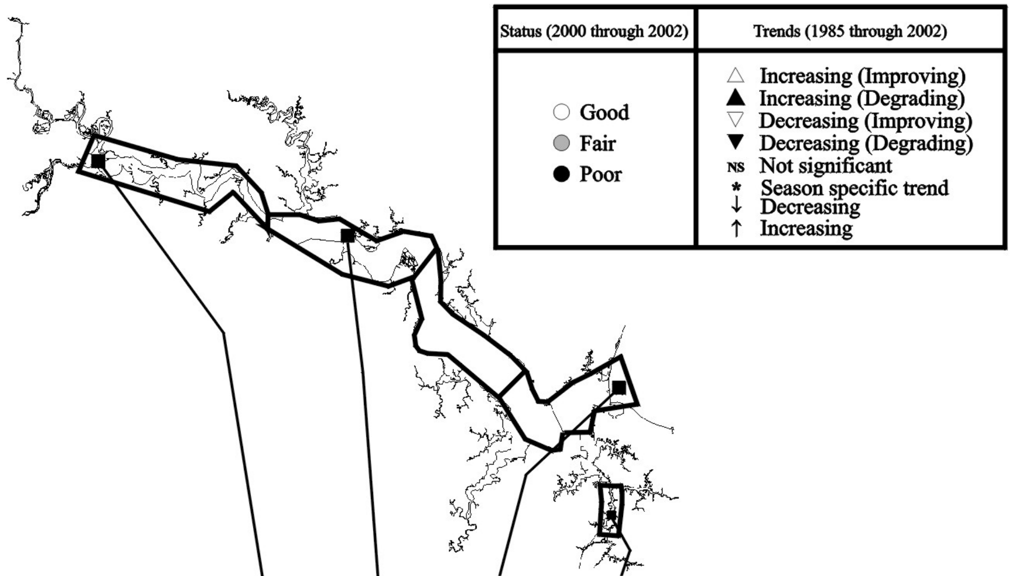
Parameter	Western Branch	Southern Branch	Eastern Branch	Elizabeth River Mainstem	Elizabeth River Mouth
STN	Good ▽	Poor ▽	Fair ▽	Good ▽	Poor NS
BTN	Good ▽	Poor NS	Fair ▽	Good NS	Poor NS
SDIN	Good ▽	Poor ▽	Poor ▽	Fair ▽	Poor NS
BDIN	Good ▽	Poor ▽	Fair ▽	Good ▽	Poor NS
STP	Poor ▽	Poor ▽	Fair ▽	Poor ▽	Poor ▲ NS
BTP	Poor ▽	Poor ▽	Fair ▽	Poor ▽	Poor NS
SDIP	Poor ▽	Poor ▽	Poor ▽	Poor ▽	Poor ▲
BDIP	Poor ▽	Poor ▽	Poor ▽	Poor ▽	Poor ▲

Figure 3-10. Map of the Elizabeth River basin showing summaries of the status and trend analyses for each segment for the period of 1989 through 2002. Abbreviations for each parameter are: TN=total nitrogen, DIN=dissolved inorganic nitrogen, TP=total phosphorus, DIP= dissolved inorganic phosphorus. The prefixes S and B refer to surface and bottom measurements, respectively.



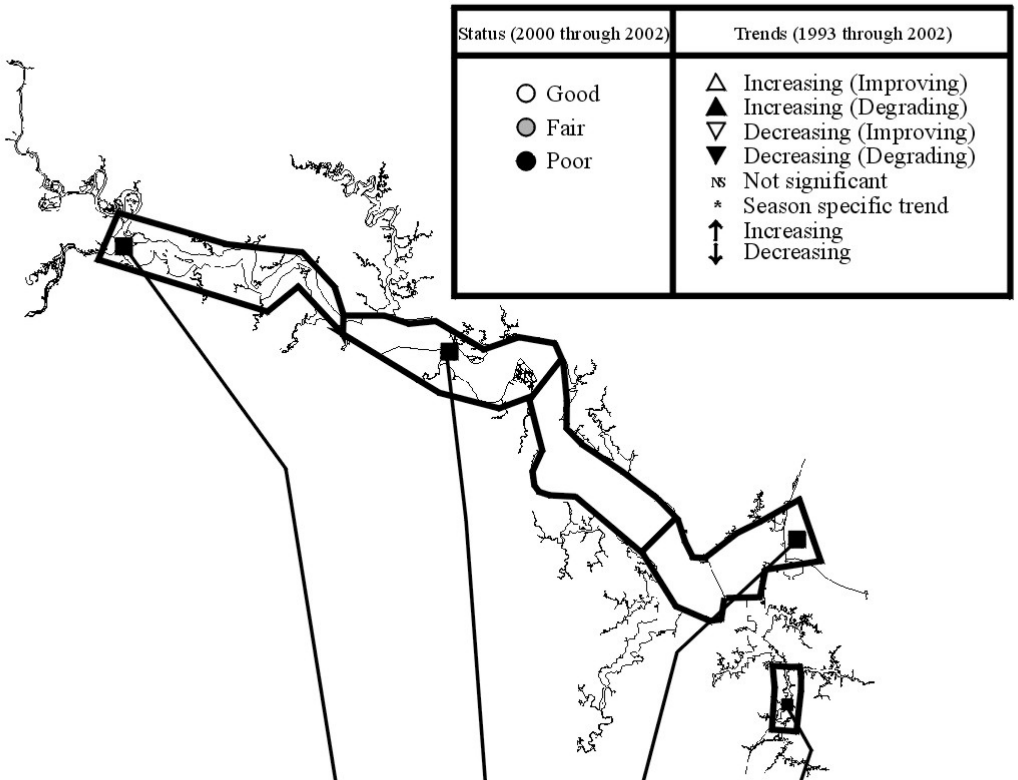
Parameter	Western Branch		Southern Branch		Eastern Branch		Elizabeth River Mainstem		Elizabeth River Mouth	
SCHLA	●	▽	○	NS	○	NS	●	NS	◍	NS
STSS	●	NS	○	▽	◍	NS	◍	NS	◍	NS
BTSS	●	NS	○	▽	○	NS	◍	NS	○	NS
SECCHI	●	△	○	△	◍	△	◍	NS	●	NS
BDO	○	△	◍	△	◍	△	○	△	○	△
SWTEMP		NS		↑		↑		↑		↑
BWTEMP		NS		↑		↑		↑		NS
SSALIN		↑		↑		↑		↑		↑
BSALIN		↑		NS		↑		NS		↑

Figure 3-11. Map of the Elizabeth River basin showing summaries of the status and trend analyses for each segment for the period of 1985 through 2002. Abbreviations for each parameter are: CHLA=chlorophyll a, TSS=total suspended solids, SECCHI=secchi depth, DO=dissolved oxygen, WTEMP=water temperature, SALIN=salinity. The prefixes S and B refer to surface and bottom measurements, respectively.



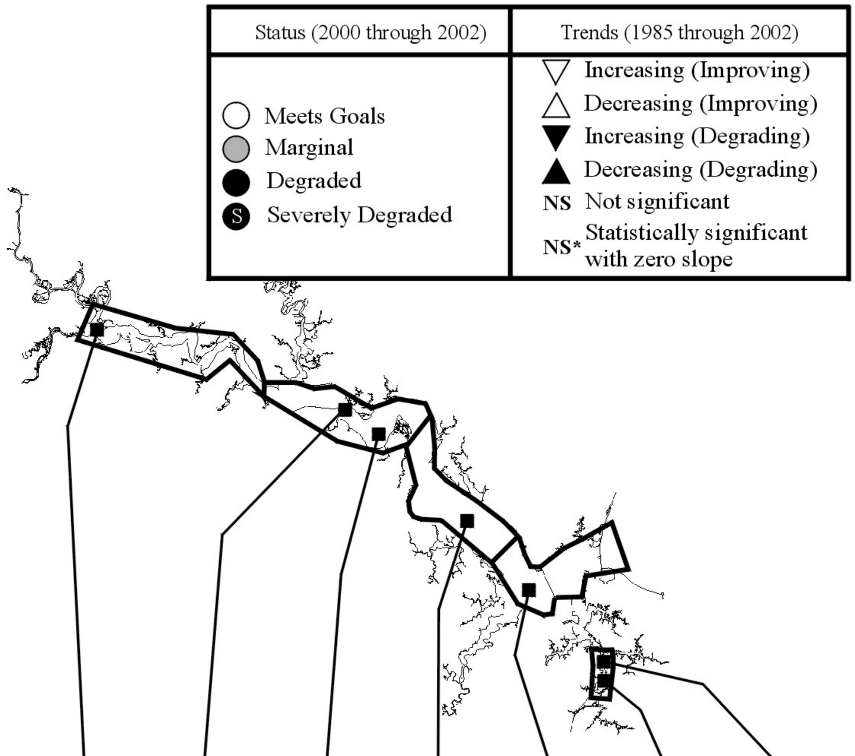
	JMSTF TF5.5	JMSOH RET5.2	JMSPH LE5.5	SBEMH SBE5
Total Abundance	↑	↑	NS	↑
Total Biomass	Good ↑	Fair ↑	Poor ↑	Poor ↑
Biomass to Abundance	Poor △	Poor △	Poor △	Poor NS
Margalef Diversity Index	Good △	Poor NS	Good NS	Good NS
Productivity	Poor NS	Good ▽	Fair ▽	Good ▽
Diatom Biomass	Good △	Good △	Fair △	Fair △
Dinoflagellate Biomass	Poor NS	Poor NS	Good NS	Fair NS
Cyanophyte Biomass	Poor ▲	Poor NS	Poor ▲	Fair ▲
Chlorophyte Biomass	Good △	Good △	Good △	Good △
Picoplankton Biomass	Poor NS	Poor ▽	Fair NS	Good NS
Cryptophyte Biomass	△	△	NS	NS
Procaryote to Eucaryote Biomass	Good NS	Good NS	Good NS	Good NS
Cyanophyte Abundance	Poor ▲	Poor ▲	Poor ▲	Fair ▲

Figure 3-12. Map of the James River basin showing summaries of the status and trend analyses for phytoplankton bioindicators for each segment for the period of 1985 through 2002.



	JMSTF TF5.5	JMSOH RET5.2	JMSPH LE5.5	SBEMH SBE5
Total Abundance	**NS**	**NS**	**NS**	↓
Total Biomass	↑	**NS**	**NS**	↓
Copepod Nauplii Abundance	○ △	◍ **NS**	● **NS**	● **NS**
Rotifer Abundance	● ▲	○ ▽	● ▲	○ **NS**
Oligotrich Abundance	↑	**NS**	**NS**	↓
Cladoceran Abundance	**NS**	**NS**	**NS**	**NS**
Tintinnid Abundance	**NS**	**NS**	**NS**	↓
Polychaeta Larvae Abundance	**NS**	**NS**	↓	↓

Figure 3-13. Map of the James River basin showing summaries of the status and trend analyses for microzooplankton bioindicators for each segment for the period of 1985 through 2002.



	JMSTF	JMSOH	JMSMH		JMSPH	SBEMH	
	TF5.5	RET5.2	LE5.1	LE5.2	LE5.4	SBE5	SBE2
Benthic IBI	○ △	○ △	○ NS	● NS	○ NS	● △	● NS
Total Abundance	△	NS	NS	△	NS	NS	△
Total Biomass	△	NS	NS	NS	NS	△	△
Pollution Sensitive Species Abundance (%)	△	△	NS	△	NS	△	△
Pollution Indicative Species Abundance (%)	▽	NS	NS*	NS	▽	▽	▽
Pollution Sensitive Species Biomass (%)	△	△	NS	NS	▼	△	△
Pollution Indicative Species Biomass (%)	▽	NS	NS	NS	NS	▽	NS
Shannon-Weiner Diversity Index	NS	△	△	NS	NS	△	NS

Figure 3-14. Map of the James River basin showing summaries of the status and trend analyses for benthic bioindicators for each segment for the period of 1985 through 2002.

Table 3-1. Water quality trends at James River RIM stations, 2035000 (James River at Cartersville), 2026000 (James River at Scottsville), 2041650 (Appomattox River at Matoaca) for the period of 1985 to 2002. All results presented are from statistical tests conducted on log-transformed data. In the Data Type column, FAC refers to flow adjusted concentrations, FWC refers to flow weighted concentrations, and LOAD refers to loadings.

Location	Station	Parameter	Data Type	Slope	% BDL	p Value	Direction
James River at Cartersville	2035000	Flow	FLOW	-0.044	0.0	<0.001	Decreasing
James River at Cartersville	2035000	TN	FAC	-0.009	-	0.037	Improving
James River at Cartersville	2035000	TN	FWC	-0.023	0.0	<0.001	Improving
James River at Cartersville	2035000	TN	LOAD	-0.067	0.0	<0.001	Improving
James River at Cartersville	2035000	NO23F	FAC	-0.038	-	<0.001	Improving
James River at Cartersville	2035000	NO23F	FWC	-0.061	0.0	<0.001	Improving
James River at Cartersville	2035000	NO23F	LOAD	-0.105	0.0	<0.001	Improving
James River at Cartersville	2035000	TP	FAC	-0.030	-	<0.001	Improving
James River at Cartersville	2035000	TP	FWC	-0.039	0.0	<0.001	Improving
James River at Cartersville	2035000	TP	LOAD	-0.084	0.0	<0.001	Improving
James River at Cartersville	2035000	PO4F	FAC	-0.059	-	<0.001	Improving
James River at Cartersville	2035000	PO4F	FWC	-0.054	0.0	<0.001	Improving
James River at Cartersville	2035000	PO4F	LOAD	-0.098	0.0	<0.001	Improving
James River at Cartersville	2035000	TSS	FWC	-0.080	0.0	0.001	Improving
James River at Cartersville	2035000	TSS	LOAD	-0.124	0.0	<0.001	Improving
James River at Scottsville	2029000	Flow	FLOW	-0.022	0.0	0.009	Improving
James River at Scottsville	2029000	TNH4	FWC	-0.042	0.0	<0.001	Improving
James River at Scottsville	2029000	TNH4	LOAD	-0.064	0.0	<0.001	Improving
James River at Scottsville	2029000	NO23W	FWC	-0.044	0.0	<0.001	Improving
James River at Scottsville	2029000	NO23W	LOAD	-0.066	0.0	<0.001	Improving
James River at Scottsville	2029000	NO3W	FAC	-0.041	5.9	<0.001	Improving
James River at Scottsville	2029000	NO3W	FWC	-0.054	0.0	<0.001	Improving
James River at Scottsville	2029000	NO3W	LOAD	-0.076	0.0	<0.001	Improving
James River at Scottsville	2029000	TP	FAC	-0.056	19.8	<0.001	Improving
James River at Scottsville	2029000	TP	LOAD	-0.079	0.0	<0.001	Improving
Appomattox River at Matoaca	2041650	Flow	FLOW	-0.067	0.0	<0.001	Improving
Appomattox River at Matoaca	2041650	TN	LOAD	-0.064	0.0	0.001	Improving
Appomattox River at Matoaca	2041650	NO23F	FAC	-0.016	-	0.032	Improving
Appomattox River at Matoaca	2041650	NO23F	LOAD	-0.065	0.0	<0.001	Improving
Appomattox River at Matoaca	2041650	TP	LOAD	-0.078	0.0	0.001	Improving
Appomattox River at Matoaca	2041650	PO4F	FAC	-0.023	-	<0.001	Improving
Appomattox River at Matoaca	2041650	PO4F	FWC	-0.014	0.0	<0.001	Improving
Appomattox River at Matoaca	2041650	PO4F	LOAD	-0.082	0.0	<0.001	Improving
Appomattox River at Matoaca	2041650	TSS	FAC	0.016	-	0.016	Degrading
Appomattox River at Matoaca	2041650	TSS	FWC	-0.030	0.0	0.019	Improving
Appomattox River at Matoaca	2041650	TSS	LOAD	-0.098	0.0	0.002	Improving

Table 3-2. Water quality status in segment JMSPH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
JMSPH	TN	ANNUAL	0.4134	11.3	Good	0.3944	13.7	Good
JMSPH	TN	SPRING1	0.4003	12.6	Good	0.3848	14.0	Good
JMSPH	TN	SPRING2	0.3961	15.3	Good	0.3930	19.1	Good
JMSPH	TN	SUMMER1	0.4711	22.0	Good	0.4781	23.2	Good
JMSPH	TN	SUMMER2	0.4738	21.8	Good	0.4860	22.5	Good
JMSPH	DIN	ANNUAL	0.0455	11.1	Good	0.0457	7.3	Good
JMSPH	DIN	SPRING1	0.0409	12.6	Good	0.0439	19.5	Good
JMSPH	DIN	SPRING2	0.0373	11.7	Good	0.0439	18.5	Good
JMSPH	DIN	SUMMER1	0.0573	17.6	Good	0.0652	2.9	Good
JMSPH	DIN	SUMMER2	0.0866	16.0	Good	0.0808	2.7	Good
JMSPH	TP	ANNUAL	0.0377	20.3	Good	0.0434	19.4	Good
JMSPH	TP	SPRING1	0.0332	17.1	Good	0.0408	18.5	Good
JMSPH	TP	SPRING2	0.0382	22.6	Good	0.0440	23.2	Good
JMSPH	TP	SUMMER1	0.0606	30.4	Good	0.0639	20.1	Good
JMSPH	TP	SUMMER2	0.0628	33.1	Good	0.0662	25.8	Good
JMSPH	PO4F	ANNUAL	0.0094	26.7	Good	0.0103	22.1	Good
JMSPH	PO4F	SPRING1	0.0062	8.9	Good	0.0061	6.3	Good
JMSPH	PO4F	SPRING2	0.0067	3.1	Good	0.0084	3.9	Good
JMSPH	PO4F	SUMMER1	0.0221	38.0	Good	0.0213	17.6	Good
JMSPH	PO4F	SUMMER2	0.0297	31.6	Good	0.0276	13.2	Good
JMSPH	CHLA	ANNUAL	7.6760	42.8	Good	-	-	-
JMSPH	CHLA	SPRING1	7.1578	12.0	Good	-	-	-
JMSPH	CHLA	SPRING2	7.6700	30.5	Good	-	-	-
JMSPH	CHLA	SUMMER1	8.6931	68.3	Poor	-	-	-
JMSPH	CHLA	SUMMER2	8.6485	75.2	Poor	-	-	-
JMSPH	TSS	ANNUAL	9.9500	44.8	Fair	16.3475	26.1	Good
JMSPH	TSS	SPRING1	11.7200	44.3	Fair	21.2125	32.6	Good
JMSPH	TSS	SPRING2	12.9900	51.5	Fair	23.0200	28.9	Good
JMSPH	TSS	SUMMER1	12.3725	55.4	Fair	19.9000	33.7	Good
JMSPH	TSS	SUMMER2	11.7550	54.5	Fair	19.8000	35.9	Good
JMSPH	SECCHI	ANNUAL	1.1500	48.6	Fair	-	-	-
JMSPH	SECCHI	SPRING1	1.1000	59.3	Good	-	-	-
JMSPH	SECCHI	SPRING2	1.0500	40.7	Poor	-	-	-
JMSPH	SECCHI	SUMMER1	1.0000	32.0	Poor	-	-	-
JMSPH	SECCHI	SUMMER2	0.9750	24.9	Poor	-	-	-
JMSPH	DO	SPRING1	-	-	-	8.5700	-	Good
JMSPH	DO	SPRING2	-	-	-	7.7550	-	Good
JMSPH	DO	SUMMER1	-	-	-	6.8543	-	Good
JMSPH	DO	SUMMER2	-	-	-	6.8385	-	Good

Table 3-3. Water quality trends in segment JMSPH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSPH	S	TN	0.0267	0.0120	0.0091	-0.0089	0.0000	Sign. Dif.	0.7054	-
JMSPH	B	TN	0.0863	0.0087	0.1577	-0.0053	0.0020	Sign. Dif.	0.7541	-
JMSPH	S	DIN	0.4374	0.0000	0.0441	0.0000	0.0044	Sign. Dif.	0.2318	-
JMSPH	B	DIN	0.2226	0.0000	0.0231	0.0000	0.0004	Sign. Dif.	0.2872	-
JMSPH	S	TP	0.7469	0.0001	0.0998	-0.0005	0.0497	Sign. Dif.	0.2026	-
JMSPH	B	TP	0.4513	0.0006	0.0222	-0.0010	0.0028	Sign. Dif.	0.1391	-
JMSPH	S	PO4F	0.9693	0.0000	0.2135	0.0000	0.1852	No Sign. Dif.	0.2406	NS
JMSPH	B	PO4F	0.7211	0.0000	0.6699	0.0000	0.9394	No Sign. Dif.	0.4033	NS

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
JMSPH	TSS	S	Annual	8.25	0.1250	27.27	7.27	0.0186	**Degrading**
JMSPH	SECCHI	S	Annual	1.30	-0.0083	-11.54	0.00	0.0120	**Degrading**
JMSPH	DO	B	Summer1	5.95	0.0456	13.79	0.00	0.0002	**Improving**
JMSPH	WTEMP	B	Annual	16.95	0.0872	9.26	0.00	0.0001	**Increasing**
JMSPH	SALINITY	B	Annual	24.83	-0.1163	-8.43	0.00	0.0004	**Decreasing**

Table 3-4. **SAV season water quality status in segment JMSPH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
JMSPH	DIN	SAV2	0.0732	16.2	Good	Meets
JMSPH	PO4F	SAV2	0.0152	41.8	Fair	Meets
JMSPH	CHLA	SAV2	5.8779	30.6	Good	Meets
JMSPH	TSS	SAV2	10.17	42	Good	Meets
JMSPH	SECCHI	SAV2	1.2	46.5	Fair	Meets

Table 3-5. **SAV Season Water quality trends in segment JMSPH (only significant trends are displayed).**

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSPH	S	TN	0.0299	0.0140	0.0617	-0.0110	0.00025	Sign. Dif.	0.82094	-
JMSPH	S	DIN	0.3334	0.0000	0.4769	0.0000	0.11320	No Sign. Dif.	0.84305	NS
JMSPH	S	TP	0.1410	0.0010	0.1292	-0.0007	0.00644	Sign. Dif.	1.00000	-
JMSPH	S	PO4F	0.6145	0.0000	0.0956	0.0002	0.29846	No Sign. Dif.	0.04236	Degrading

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	% BDL	Direction
JMSPH	B	SAV2	WTEMP	16.58	0.10	11.19	0.0056	0.00	Increasing

Table 3-6. Water quality status in segment JMSMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
JMSMH	TN	ANNUAL	0.4663	10.1	Good	0.5115	12.5	Good
JMSMH	TN	SPRING1	0.4755	11.4	Good	0.5575	14.1	Good
JMSMH	TN	SPRING2	0.4755	9.5	Good	0.5575	20.1	Good
JMSMH	TN	SUMMER1	0.4810	7.3	Good	0.5725	14.5	Good
JMSMH	TN	SUMMER2	0.4945	5.6	Good	0.5778	14.0	Good
JMSMH	DIN	ANNUAL	0.1075	48.4	Fair	0.0875	30.0	Good
JMSMH	DIN	SPRING1	0.1550	64.7	Poor	0.1255	58.2	Poor
JMSMH	DIN	SPRING2	0.1320	61.8	Poor	0.1105	54.5	Fair
JMSMH	DIN	SUMMER1	0.0938	69.8	Poor	0.1023	57.4	Fair
JMSMH	DIN	SUMMER2	0.1075	71.9	Poor	0.1130	62.6	Poor
JMSMH	TP	ANNUAL	0.0544	63.8	Poor	0.0680	70.0	Poor
JMSMH	TP	SPRING1	0.0484	55.3	Fair	0.0650	57.7	Poor
JMSMH	TP	SPRING2	0.0544	60.4	Poor	0.0713	63.3	Poor
JMSMH	TP	SUMMER1	0.0753	79.8	Poor	0.0903	77.1	Poor
JMSMH	TP	SUMMER2	0.0775	83.0	Poor	0.1000	82.0	Poor
JMSMH	PO4F	ANNUAL	0.0220	84.8	Poor	0.0215	82.3	Poor
JMSMH	PO4F	SPRING1	0.0165	87.3	Poor	0.0128	80.6	Poor
JMSMH	PO4F	SPRING2	0.0185	86.5	Poor	0.0190	83.1	Poor
JMSMH	PO4F	SUMMER1	0.0375	91.3	Poor	0.0365	88.6	Poor
JMSMH	PO4F	SUMMER2	0.0485	92.2	Poor	0.0460	90.9	Poor
JMSMH	CHLA	ANNUAL	6.6000	22.0	Good	-	-	-
JMSMH	CHLA	SPRING1	6.5750	12.1	Good	-	-	-
JMSMH	CHLA	SPRING2	5.1750	12.4	Good	-	-	-
JMSMH	CHLA	SUMMER1	6.2238	11.7	Good	-	-	-
JMSMH	CHLA	SUMMER2	6.6250	10.2	Good	-	-	-
JMSMH	TSS	ANNUAL	13.0000	50.4	Fair	29.0000	62.9	Poor
JMSMH	TSS	SPRING1	17.5000	59.5	Poor	28.5000	62.0	Poor
JMSMH	TSS	SPRING2	16.0000	54.9	Fair	57.5000	67.9	Poor
JMSMH	TSS	SUMMER1	13.5000	51.8	Fair	43.2500	69.0	Poor
JMSMH	TSS	SUMMER2	13.5000	54.2	Fair	44.0000	68.8	Poor
JMSMH	SECCHI	ANNUAL	0.9500	46.3	Fair	-	-	-
JMSMH	SECCHI	SPRING1	0.7000	38.6	Poor	-	-	-
JMSMH	SECCHI	SPRING2	0.8000	46.0	Fair	-	-	-
JMSMH	SECCHI	SUMMER1	0.8750	49.7	Fair	-	-	-
JMSMH	SECCHI	SUMMER2	0.8500	47.4	Fair	-	-	-
JMSMH	DO	SPRING1	-	-	-	8.0850	-	Good
JMSMH	DO	SPRING2	-	-	-	6.6600	-	Good
JMSMH	DO	SUMMER1	-	-	-	6.1500	-	Good
JMSMH	DO	SUMMER2	-	-	-	6.3000	-	Good

Table 3-7. Water quality trends in segment JMSMH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSMH	S	TN	0.1264	0.0100	0.0257	-0.0096	0.0002	Sign. Dif.	0.4843	-
JMSMH	B	TN	0.0746	0.0144	0.3075	-0.0058	0.0056	Sign. Dif.	0.4830	-
JMSMH	S	DIN	0.2788	0.0050	0.2380	-0.0043	0.0221	Sign. Dif.	0.9041	-
JMSMH	B	DIN	0.6578	0.0000	0.0722	0.0000	0.0222	Sign. Dif.	0.1701	-
JMSMH	S	TP	0.0000	0.0050	0.5819	-0.0005	0.0000	Sign. Dif.	0.0000	-
JMSMH	B	TP	0.0000	0.0050	0.9122	-0.0002	0.0000	Sign. Dif.	0.0000	-
JMSMH	S	PO4F	0.0000	0.0025	0.1419	0.0007	0.0103	Sign. Dif.	0.0000	-
JMSMH	B	PO4F	0.0001	0.0025	0.0333	0.0005	0.1395	No Sign. Dif.	0.0000	**Degrading**

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
JMSMH	TSS	B	Annual	142.00	0.7361	9.33	3.05	0.0032	**Degrading**
JMSMH	SALINITY	S	Annual	14.96	0.1793	21.58	0.00	0.0014	**Increasing**
JMSMH	SALINITY	B	Annual	18.35	0.0964	9.46	0.00	0.0286	**Increasing**

Table 3-8. SAV season water quality status in segment JMSMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
JMSMH	DIN	SAV1	0.132	66.1	**Poor**	**Meets**
JMSMH	PO4F	SAV1	0.027	87.7	**Poor**	**Fails**
JMSMH	CHLA	SAV1	4.89	11	**Good**	**Meets**
JMSMH	TSS	SAV1	14	52.8	**Fair**	**Meets**
JMSMH	SECCHI	SAV1	0.85	48.3	**Fair**	**Fails**

Table 3-9. SAV Season Water quality trends in segment JMSMH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSMH	S	TN	0.0829	0.0129	0.8062	0.0015	0.1291	No Sign. Dif.	0.0353	**Degrading**
JMSMH	S	DIN	0.0281	0.0150	0.5141	0.0000	0.1578	No Sign. Dif.	0.0074	**Degrading**
JMSMH	S	TP	0.0000	0.0057	0.2821	0.0020	0.0000	Sign. Dif.	0.0000	-
JMSMH	S	PO4F	0.0000	0.0032	0.0753	0.0010	0.0101	Sign. Dif.	0.0000	-

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
JMSMH	S	SAV1	SALINITY	15.82	0.1250	14.22	0.0473	0.00	**Increasing**

Table 3-10. Water quality status in segment JMSOH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
JMSOH	TN	ANNUAL	0.6515	11.5	Good	0.7520	13.6	Good
JMSOH	TN	SPRING1	0.8060	18.4	Good	0.9365	24.8	Good
JMSOH	TN	SPRING2	0.6490	12.0	Good	0.8980	27.6	Good
JMSOH	TN	SUMMER1	0.4808	1.2	Good	0.5678	5.0	Good
JMSOH	TN	SUMMER2	0.4980	1.2	Good	0.5730	6.1	Good
JMSOH	DIN	ANNUAL	0.1879	32.1	Good	0.1800	30.1	Good
JMSOH	DIN	SPRING1	0.3035	36.9	Good	0.3073	38.7	Good
JMSOH	DIN	SPRING2	0.1879	24.3	Good	0.1850	24.7	Good
JMSOH	DIN	SUMMER1	0.0665	5.3	Good	0.0743	12.8	Good
JMSOH	DIN	SUMMER2	0.0555	6.6	Good	0.0695	11.0	Good
JMSOH	TP	ANNUAL	0.0800	37.5	Good	0.1129	44.6	Fair
JMSOH	TP	SPRING1	0.0790	21.4	Good	0.1220	43.4	Fair
JMSOH	TP	SPRING2	0.0800	25.5	Good	0.1220	45.0	Fair
JMSOH	TP	SUMMER1	0.0851	54.0	Fair	0.1114	43.8	Fair
JMSOH	TP	SUMMER2	0.0849	59.9	Poor	0.1094	44.2	Fair
JMSOH	PO4F	ANNUAL	0.0255	79.2	Poor	0.0265	80.2	Poor
JMSOH	PO4F	SPRING1	0.0158	57.6	Fair	0.0170	60.0	Poor
JMSOH	PO4F	SPRING2	0.0206	77.6	Poor	0.0209	80.9	Poor
JMSOH	PO4F	SUMMER1	0.0320	89.8	Poor	0.0345	87.9	Poor
JMSOH	PO4F	SUMMER2	0.0345	92.6	Poor	0.0370	91.4	Poor
JMSOH	CHLA	ANNUAL	7.0250	40.5	Good	-	-	-
JMSOH	CHLA	SPRING1	8.8050	66.2	Poor	-	-	-
JMSOH	CHLA	SPRING2	8.8050	46.4	Fair	-	-	-
JMSOH	CHLA	SUMMER1	8.2725	24.5	Good	-	-	-
JMSOH	CHLA	SUMMER2	7.9300	16.1	Good	-	-	-
JMSOH	TSS	ANNUAL	22.5000	27.3	Good	58.7500	51.5	Fair
JMSOH	TSS	SPRING1	25.5000	23.4	Good	95.0000	68.1	Poor
JMSOH	TSS	SPRING2	28.6250	26.8	Good	102.5000	71.0	Poor
JMSOH	TSS	SUMMER1	21.0000	34.9	Good	49.0000	38.4	Good
JMSOH	TSS	SUMMER2	19.5000	36.1	Good	46.5000	41.2	Good
JMSOH	SECCHI	ANNUAL	0.5500	81.6	Good	-	-	-
JMSOH	SECCHI	SPRING1	0.4500	76.5	Good	-	-	-
JMSOH	SECCHI	SPRING2	0.4500	66.6	Good	-	-	-
JMSOH	SECCHI	SUMMER1	0.5750	51.7	Fair	-	-	-
JMSOH	SECCHI	SUMMER2	0.6000	68.3	Good	-	-	-
JMSOH	DO	SPRING1	-	-	-	8.8400	-	Good
JMSOH	DO	SPRING2	-	-	-	6.9150	-	Good
JMSOH	DO	SUMMER1	-	-	-	6.4225	-	Good
JMSOH	DO	SUMMER2	-	-	-	6.6050	-	Good

Table 3-11. Water quality trends in segment JMSOH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSOH	S	TN	0.0714	-0.0141	0.1800	-0.0108	0.6644	No Sign. Dif.	0.0019	**Improving**
JMSOH	B	TN	0.0615	0.0185	0.0279	-0.0268	0.0001	Sign. Dif.	0.7165	-
JMSOH	S	DIN	0.0445	-0.0138	0.0514	-0.0100	0.9097	No Sign. Dif.	0.0001	**Improving**
JMSOH	B	DIN	0.0490	-0.0145	0.0476	-0.0083	1.0000	No Sign. Dif.	0.0001	**Improving**
JMSOH	S	TP	0.0010	0.0050	0.4855	-0.0011	0.0001	Sign. Dif.	0.0151	-
JMSOH	B	TP	0.0000	0.0123	0.0029	-0.0082	0.0000	Sign. Dif.	0.0934	-
JMSOH	S	PO4F	0.1047	0.0000	0.0929	0.0009	0.8577	No Sign. Dif.	0.0014	**Degrading**
JMSOH	B	PO4F	0.0760	0.0000	0.0179	0.0011	0.4745	No Sign. Dif.	0.0001	**Degrading**

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
JMSOH	TSS	S	Annual	662.00	-0.6667	-1.81	2.30	0.0050	**Improving**
JMSOH	SECCHI	S	Annual	0.53	0.0028	9.64	0.00	0.0281	**Improving**
JMSOH	SALINITY	S	Annual	2.72	0.0983	65.13	0.00	0.0000	**Increasing**
JMSOH	SALINITY	B	Annual	3.47	0.1500	77.81	0.00	0.0000	**Increasing**

Table 3-12. SAV season water quality status in segment JMSOH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
JMSOH	DIN	SAV1	0.1225	20.5	Good	-
JMSOH	PO4F	SAV1	0.0285	88.6	Poor	Fails
JMSOH	CHLA	SAV1	7.865	28.6	Good	Meets
JMSOH	TSS	SAV1	23.5	32.4	Good	Fails
JMSOH	SECCHI	SAV1	0.55	62.7	Good	Fails

Table 3-13. SAV Season Water quality trends in segment JMSOH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSOH	S	TN	0.1472	-0.0108	0.8481	-0.0020	0.2143	No Sign. Dif.	0.0855	NS
JMSOH	S	DIN	0.1169	-0.0116	0.9576	0.0000	0.0630	No Sign. Dif.	0.0996	NS
JMSOH	S	TP	0.0019	0.0058	0.4830	0.0009	0.0196	Sign. Dif.	0.0001	-
JMSOH	S	PO4F	0.0037	0.0013	0.0001	0.0017	0.3052	No Sign. Dif.	0.0000	Degrading

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
JMSOH	S	SAV1	SALINITY	3.85	0.0942	44.03	0.0070	0.00	Increasing

Table 3-14. Water quality status in segment JMSTF (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
JMSTF	TN	ANNUAL	0.8805	33.0	Good	1.0385	36.2	Good
JMSTF	TN	SPRING1	0.8255	32.5	Good	0.9075	32.7	Good
JMSTF	TN	SPRING2	0.7550	27.8	Good	0.9135	41.6	Good
JMSTF	TN	SUMMER1	0.8805	34.2	Good	1.1010	36.1	Good
JMSTF	TN	SUMMER2	0.8903	35.1	Good	1.1115	41.1	Good
JMSTF	DIN	ANNUAL	0.3340	40.9	Fair	0.3650	39.2	Good
JMSTF	DIN	SPRING1	0.3355	33.1	Good	0.3790	33.0	Good
JMSTF	DIN	SPRING2	0.2940	25.5	Good	0.3430	24.3	Good
JMSTF	DIN	SUMMER1	0.1290	14.6	Good	0.1710	21.1	Good
JMSTF	DIN	SUMMER2	0.1155	13.3	Good	0.1590	30.6	Good
JMSTF	TP	ANNUAL	0.0847	36.7	Good	0.1101	46.9	Fair
JMSTF	TP	SPRING1	0.0798	36.1	Good	0.0981	47.6	Fair
JMSTF	TP	SPRING2	0.0814	32.3	Good	0.1228	46.0	Fair
JMSTF	TP	SUMMER1	0.0902	32.9	Good	0.1176	43.8	Fair
JMSTF	TP	SUMMER2	0.0890	31.0	Good	0.1130	45.1	Fair
JMSTF	PO4F	ANNUAL	0.0260	41.2	Fair	0.0220	42.5	Fair
JMSTF	PO4F	SPRING1	0.0245	41.4	Good	0.0220	42.9	Good
JMSTF	PO4F	SPRING2	0.0245	44.3	Fair	0.0220	41.6	Good
JMSTF	PO4F	SUMMER1	0.0305	44.6	Fair	0.0260	48.7	Fair
JMSTF	PO4F	SUMMER2	0.0350	46.5	Fair	0.0260	50.6	Fair
JMSTF	CHLA	ANNUAL	10.4500	60.5	Poor	-	-	-
JMSTF	CHLA	SPRING1	6.4550	68.4	Poor	-	-	-
JMSTF	CHLA	SPRING2	15.9400	74.3	Poor	-	-	-
JMSTF	CHLA	SUMMER1	19.6988	66.9	Poor	-	-	-
JMSTF	CHLA	SUMMER2	19.5575	61.1	Poor	-	-	-
JMSTF	TSS	ANNUAL	14.2500	60.0	Poor	43.5000	68.3	Poor
JMSTF	TSS	SPRING1	20.0000	58.2	Poor	43.0000	67.5	Poor
JMSTF	TSS	SPRING2	15.5000	61.2	Poor	43.0000	50.1	Fair
JMSTF	TSS	SUMMER1	14.0000	39.1	Good	46.0000	67.3	Poor
JMSTF	TSS	SUMMER2	13.7500	42.7	Good	59.0000	78.4	Poor
JMSTF	SECCHI	ANNUAL	0.5000	28.8	Poor	-	-	-
JMSTF	SECCHI	SPRING1	0.5000	27.1	Poor	-	-	-
JMSTF	SECCHI	SPRING2	0.5000	25.9	Poor	-	-	-
JMSTF	SECCHI	SUMMER1	0.5000	22.6	Poor	-	-	-
JMSTF	SECCHI	SUMMER2	0.5000	40.5	Poor	-	-	-
JMSTF	DO	SPRING1	-	-	-	8.6600	-	Good
JMSTF	DO	SPRING2	-	-	-	7.5500	-	Good
JMSTF	DO	SUMMER1	-	-	-	6.8850	-	Good
JMSTF	DO	SUMMER2	-	-	-	6.8900	-	Good

Table 3-15. Water quality trends in segment JMSTF (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	‘93 Trend p value	‘93 Slope	‘02 Trend p value	‘02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSTF	S	TN	0.0006	-0.0478	0.1070	0.0144	0.0000	Sign. Dif.	0.0586	-
JMSTF	B	TN	0.0044	-0.0475	0.1248	0.0133	0.0000	Sign. Dif.	0.2036	-
JMSTF	S	DIN	0.0012	-0.0267	0.0633	-0.0090	0.1833	No Sign. Dif.	0.0000	**Improving**
JMSTF	B	DIN	0.0000	-0.0352	0.1281	-0.0100	0.0091	Sign. Dif.	0.0000	-
JMSTF	S	TP	0.0076	-0.0050	0.1921	0.0010	0.0001	Sign. Dif.	0.1926	-
JMSTF	B	TP	0.0134	-0.0050	0.8521	0.0006	0.0089	Sign. Dif.	0.0294	-
JMSTF	S	PO4F	0.0000	-0.0063	0.3095	-0.0007	0.0002	Sign. Dif.	0.0000	-
JMSTF	B	PO4F	0.0052	-0.0025	0.5111	-0.0003	0.0537	No Sign. Dif.	0.0010	**Improving**

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
JMSTF	CHLA	S	Annual	6.67	0.1575	42.50	25.20	0.0023	**Degrading**
JMSTF	TSS	B	Annual	172.00	0.8000	8.37	3.00	0.0357	**Degrading**
JMSTF	SECCHI	S	Annual	0.70	0.0000	0.00	0.00	0.0027	**Degrading**
JMSTF	DO	B	Summer1	6.35	0.0442	12.52	0.00	0.0031	**Improving**
JMSTF	WTEMP	S	Annual	17.88	0.0625	6.29	0.00	0.0149	**Increasing**
JMSTF	WTEMP	B	Annual	18.48	0.0625	6.09	0.00	0.0221	**Increasing**
JMSTF	SALINITY	S	Annual	0.01	0.0000	0.00	0.00	0.0000	**Increasing**
JMSTF	SALINITY	B	Annual	0.01	0.0000	0.00	0.00	0.0000	**Increasing**

Table 3-16. SAV season water quality status in segment JMSTF (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
JMSTF	DIN	SAV1	0.1855	26	Good	-
JMSTF	PO4F	SAV1	0.028	43.5	Fair	Fails
JMSTF	CHLA	SAV1	18.6425	69.9	Poor	Fails
JMSTF	TSS	SAV1	13.75	42.3	Good	Meets
JMSTF	SECCHI	SAV1	0.5	25.9	Poor	Fails

Table 3-17. SAV Season Water quality trends in segment JMSTF (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
JMSTF	S	TN	0.0002	-0.0517	0.2591	0.0115	0.0000	Sign. Dif.	0.0053	-
JMSTF	S	DIN	0.0005	-0.0306	0.0096	-0.0178	0.3062	No Sign. Dif.	0.0000	Improving
JMSTF	S	TP	0.0016	-0.0059	0.2612	0.0012	0.0000	Sign. Dif.	0.0552	-
JMSTF	S	PO4F	0.0001	-0.0050	1.0000	0.0000	0.0001	Sign. Dif.	0.0001	-

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
JMSTF	S	SAV1	CHLA	10.80	0.2951	49.19	0.0433	21.94	Degrading
JMSTF	S	SAV1	SECCHI	0.70	-0.0044	-11.20	0.0021	0.00	Degrading
JMSTF	S	SAV1	WTEMP	23.78	0.0900	6.81	0.0077	0.00	Increasing
JMSTF	S	SAV1	SALINITY	0.01	0.0000	0.00	0.0000	0.00	Increasing

Table 3-18. Water quality status in segment APPTF (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
APPTF	TN	ANNUAL	0.9390	45.5	Fair	0.9330	30.2	Good
APPTF	TN	SPRING1	0.7850	37.3	Good	0.8825	35.4	Good
APPTF	TN	SPRING2	0.9450	57.7	Fair	0.9015	32.3	Good
APPTF	TN	SUMMER1	1.0550	51.9	Fair	1.0870	41.1	Good
APPTF	TN	SUMMER2	1.0490	48.4	Fair	1.0920	40.1	Good
APPTF	DIN	ANNUAL	0.2690	23.8	Good	0.2710	18.0	Good
APPTF	DIN	SPRING1	0.2225	8.8	Good	0.2045	3.8	Good
APPTF	DIN	SPRING2	0.1290	2.5	Good	0.1395	0.8	Good
APPTF	DIN	SUMMER1	0.1725	15.8	Good	0.1520	8.6	Good
APPTF	DIN	SUMMER2	0.1800	20.1	Good	0.1590	12.9	Good
APPTF	TP	ANNUAL	0.0942	45.4	Fair	0.1046	44.0	Fair
APPTF	TP	SPRING1	0.0763	34.3	Good	0.0950	42.7	Fair
APPTF	TP	SPRING2	0.1086	64.6	Poor	0.1178	54.3	Fair
APPTF	TP	SUMMER1	0.1156	57.7	Fair	0.1300	53.9	Fair
APPTF	TP	SUMMER2	0.1117	51.5	Fair	0.1315	55.1	Fair
APPTF	PO4F	ANNUAL	0.0160	27.0	Good	0.0150	26.2	Good
APPTF	PO4F	SPRING1	0.0135	23.1	Good	0.0110	15.3	Good
APPTF	PO4F	SPRING2	0.0160	27.5	Good	0.0150	25.7	Good
APPTF	PO4F	SUMMER1	0.0180	29.7	Good	0.0175	31.3	Good
APPTF	PO4F	SUMMER2	0.0160	25.6	Good	0.0150	26.0	Good
APPTF	CHLA	ANNUAL	26.5200	89.6	Poor	-	-	-
APPTF	CHLA	SPRING1	11.2500	76.4	Poor	-	-	-
APPTF	CHLA	SPRING2	38.8800	94.0	Poor	-	-	-
APPTF	CHLA	SUMMER1	44.6300	88.8	Poor	-	-	-
APPTF	CHLA	SUMMER2	47.6300	88.8	Poor	-	-	-
APPTF	TSS	ANNUAL	23.0000	75.1	Poor	31.5000	61.4	Poor
APPTF	TSS	SPRING1	19.5000	59.9	Poor	36.5000	62.5	Poor
APPTF	TSS	SPRING2	30.5000	85.9	Poor	47.0000	77.5	Poor
APPTF	TSS	SUMMER1	31.0000	90.2	Poor	50.0000	85.6	Poor
APPTF	TSS	SUMMER2	32.0000	90.4	Poor	43.5000	80.4	Poor
APPTF	SECCHI	ANNUAL	0.5000	28.8	Poor	-	-	-
APPTF	SECCHI	SPRING1	0.4000	13.8	Poor	-	-	-
APPTF	SECCHI	SPRING2	0.4000	11.8	Poor	-	-	-
APPTF	SECCHI	SUMMER1	0.5000	22.6	Poor	-	-	-
APPTF	SECCHI	SUMMER2	0.5000	22.6	Poor	-	-	-
APPTF	DO	SPRING1	-	-	-	9.0450	-	Good
APPTF	DO	SPRING2	-	-	-	7.6100	-	Good
APPTF	DO	SUMMER1	-	-	-	7.2400	-	Good
APPTF	DO	SUMMER2	-	-	-	7.7800	-	Good

Table 3-19. Water quality trends in segment APPTF (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
APPTF	S	TN	0.1041	-0.0150	0.0005	0.0198	0.0000	Sign. Dif.	0.0909	-
APPTF	B	TN	0.2809	-0.0100	0.0570	0.0145	0.0024	Sign. Dif.	0.4546	-
APPTF	S	DIN	0.9397	0.0000	0.1912	-0.0100	0.1556	No Sign. Dif.	0.2342	NS
APPTF	B	DIN	0.6438	-0.0017	0.0296	-0.0158	0.0978	No Sign. Dif.	0.0079	**Improving**
APPTF	S	TP	0.8198	0.0000	0.3015	0.0018	0.1931	No Sign. Dif.	0.4349	NS
APPTF	B	TP	0.1461	0.0020	0.3735	0.0014	0.5723	No Sign. Dif.	0.0177	**Degrading**
APPTF	S	PO4F	0.0155	-0.0013	0.1253	-0.0004	0.4300	No Sign. Dif.	0.0001	**Improving**
APPTF	B	PO4F	0.0090	-0.0017	0.1372	-0.0003	0.2834	No Sign. Dif.	0.0000	**Improving**

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
APPTF	DO	B	Summer1	8.20	0.0500	10.98	0.00	0.0345	**Improving**
APPTF	WTEMP	S	Annual	19.68	0.1000	9.15	0.00	0.0024	**Increasing**
APPTF	WTEMP	B	Annual	19.00	0.1036	9.81	0.00	0.0032	**Increasing**
APPTF	SALINITY	S	Annual	0.01	0.0000	0.00	0.00	0.0000	**Increasing**
APPTF	SALINITY	B	Annual	0.01	0.0000	0.00	0.00	0.0000	**Increasing**

Table 3-20. SAV season water quality status in segment APPTF (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
APPTF	DIN	SAV1	0.1725	13.3	**Good**	-
APPTF	PO4F	SAV1	0.016	26.3	**Good**	**Meets**
APPTF	CHLA	SAV1	41.63	90.9	**Poor**	**Fails**
APPTF	TSS	SAV1	30	84.3	**Poor**	**Fails**
APPTF	SECCHI	SAV1	0.4	11.8	**Poor**	**Fails**

Table 3-21. SAV Season Water quality trends in segment APPTF (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
APPTF	S	TN	0.0755	-0.0350	0.0129	0.0209	0.0000	Sign. Dif.	0.6343	-
APPTF	S	DIN	0.5652	0.0025	0.0220	-0.0199	0.0029	Sign. Dif.	0.1105	-
APPTF	S	TP	0.1234	-0.0033	0.3378	0.0028	0.0111	Sign. Dif.	0.5983	-
APPTF	S	PO4F	0.1155	-0.0009	0.6172	0.0000	0.3684	No Sign. Dif.	0.0589	NS

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
APPTF	S	SAV1	WTEMP	22.75	0.1046	8.27	0.0079	0.00	**Increasing**
APPTF	S	SAV1	SALINITY	0.01	0.0000	0.00	0.0002	0.00	**Increasing**

Table 3-22. Water quality status in segment CHKOH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
CHKOH	TN	ANNUAL	0.6935	16.8	**Good**	0.7215	13.8	**Good**
CHKOH	TN	SPRING1	0.7550	20.1	**Good**	0.7140	8.2	**Good**
CHKOH	TN	SPRING2	0.6670	14.3	**Good**	0.7140	10.4	**Good**
CHKOH	TN	SUMMER1	0.6280	12.7	**Good**	0.7130	17.9	**Good**
CHKOH	TN	SUMMER2	0.6220	12.2	**Good**	0.6910	17.8	**Good**
CHKOH	DIN	ANNUAL	0.0510	2.8	**Good**	0.0490	2.1	**Good**
CHKOH	DIN	SPRING1	0.0600	0.9	**Good**	0.0450	0.5	**Good**
CHKOH	DIN	SPRING2	0.0510	0.6	**Good**	0.0490	0.6	**Good**
CHKOH	DIN	SUMMER1	0.0125	0.2	**Good**	0.0105	0.1	**Good**
CHKOH	DIN	SUMMER2	0.0120	0.2	**Good**	0.0110	0.0	**Good**
CHKOH	TP	ANNUAL	0.0752	35.4	**Good**	0.0946	35.4	**Good**
CHKOH	TP	SPRING1	0.0856	31.0	**Good**	0.0902	20.8	**Good**
CHKOH	TP	SPRING2	0.0857	34.0	**Good**	0.0937	22.3	**Good**
CHKOH	TP	SUMMER1	0.0780	44.0	**Fair**	0.1137	47.7	**Fair**
CHKOH	TP	SUMMER2	0.0800	53.1	**Fair**	0.1075	47.6	**Fair**
CHKOH	PO4F	ANNUAL	0.0100	24.1	**Good**	0.0100	22.1	**Good**
CHKOH	PO4F	SPRING1	0.0070	9.6	**Good**	0.0070	9.6	**Good**
CHKOH	PO4F	SPRING2	0.0090	14.7	**Good**	0.0090	15.8	**Good**
CHKOH	PO4F	SUMMER1	0.0115	34.3	**Good**	0.0125	33.4	**Good**
CHKOH	PO4F	SUMMER2	0.0120	39.3	**Fair**	0.0130	37.0	**Good**
CHKOH	CHLA	ANNUAL	18.4800	89.9	**Poor**	-	-	-
CHKOH	CHLA	SPRING1	25.4200	93.6	**Poor**	-	-	-
CHKOH	CHLA	SPRING2	23.8000	94.3	**Poor**	-	-	-
CHKOH	CHLA	SUMMER1	18.2450	87.5	**Poor**	-	-	-
CHKOH	CHLA	SUMMER2	18.0100	84.9	**Poor**	-	-	-
CHKOH	TSS	ANNUAL	21.0000	27.3	**Good**	32.5000	26.6	**Good**
CHKOH	TSS	SPRING1	21.0000	11.5	**Good**	28.3333	11.0	**Good**
CHKOH	TSS	SPRING2	22.0000	14.7	**Good**	28.3333	12.0	**Good**
CHKOH	TSS	SUMMER1	22.0000	34.9	**Good**	58.0000	55.5	**Fair**
CHKOH	TSS	SUMMER2	23.0000	45.5	**Fair**	53.5000	52.7	**Fair**
CHKOH	SECCHI	ANNUAL	0.5000	68.1	**Good**	-	-	-
CHKOH	SECCHI	SPRING1	0.4000	76.5	**Good**	-	-	-
CHKOH	SECCHI	SPRING2	0.4500	76.6	**Good**	-	-	-
CHKOH	SECCHI	SUMMER1	0.5000	51.7	**Fair**	-	-	-
CHKOH	SECCHI	SUMMER2	0.5000	40.6	**Poor**	-	-	-
CHKOH	DO	SPRING1	-	-	-	8.1700	-	**Good**
CHKOH	DO	SPRING2	-	-	-	6.8100	-	**Good**
CHKOH	DO	SUMMER1	-	-	-	6.1850	-	**Good**
CHKOH	DO	SUMMER2	-	-	-	6.3400	-	**Good**

Table 3-23. Water quality trends in segment CHKOH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
CHKOH	S	TN	0.0407	-0.0550	0.3910	-0.0060	0.6715	No Sign. Dif.	0.0268	Improving
CHKOH	B	TN	0.1611	-0.0442	0.1977	-0.0207	0.6705	No Sign. Dif.	0.0263	Improving
CHKOH	S	DIN	0.0000	0.0000	0.1990	0.0000	0.1998	No Sign. Dif.	0.1603	NS
CHKOH	B	DIN	0.7787	0.0000	0.3323	0.0000	0.2036	No Sign. Dif.	0.4312	NS
CHKOH	S	TP	0.2649	0.0006	0.1801	-0.0020	0.0389	Sign. Dif.	0.4911	-
CHKOH	B	TP	0.2184	0.0050	0.6774	-0.0011	0.2164	No Sign. Dif.	0.7486	NS
CHKOH	S	PO4F	0.3640	0.0000	0.0842	0.0000	0.2281	No Sign. Dif.	0.0414	Improving
CHKOH	B	PO4F	0.0902	0.0000	0.0138	0.0000	0.1116	No Sign. Dif.	0.0006	Improving

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
CHKOH	TSS	S	Annual	17.50	0.5812	46.49	0.00	0.0037	Degrading
CHKOH	TSS	B	Annual	27.00	1.4167	73.46	0.00	0.0003	Degrading
CHKOH	SECCHI	S	Annual	0.60	0.0000	0.00	0.00	0.0011	Degrading
CHKOH	SALINITY	S	Annual	0.01	0.0000	0.00	0.00	0.0000	Increasing
CHKOH	SALINITY	B	Annual	0.01	0.0000	0.00	0.00	0.0000	Increasing

Table 3-24. SAV season water quality status in segment CHKOH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
CHKOH	DIN	SAV1	0.02	0.4	Good	-
CHKOH	PO4F	SAV1	0.011	28.4	Good	Meets
CHKOH	CHLA	SAV1	18.58	87.9	Poor	Fails
CHKOH	TSS	SAV1	22.5	29.9	Good	Fails
CHKOH	SECCHI	SAV1	0.5	62.7	Good	Fails

Table 3-25. SAV Season Water quality trends in segment CHKOH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
CHKOH	S	TN	0.0156	-0.0704	0.3375	-0.0095	0.5900	No Sign. Dif.	0.0100	Improving
CHKOH	S	DIN	0.7105	0.0000	0.6086	0.0000	0.4777	No Sign. Dif.	0.9371	NS
CHKOH	S	TP	0.4925	0.0000	0.4145	-0.0013	0.1998	No Sign. Dif.	0.7266	NS
CHKOH	S	PO4F	0.4642	0.0000	0.3047	0.0000	0.5568	No Sign. Dif.	0.1961	NS

b) Non nutrient parameters

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
CHKOH	S	SAV1	TSS	17.50	0.5000	40.00	0.0088	0.00	Degrading
CHKOH	S	SAV1	SECCHI	0.60	-0.0056	-12.96	0.0062	0.00	Degrading
CHKOH	S	SAV1	SALINITY	0.01	0.0000	0.00	0.0003	0.00	Increasing

Table 3-26. Water quality status in segment ELIPH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
ELIPH	TN	ANNUAL	0.5375	37.9	Good	0.5100	38.1	Good
ELIPH	TN	SPRING1	0.5660	49.5	Fair	0.5100	44.5	Fair
ELIPH	TN	SPRING2	0.5480	49.8	Fair	0.5140	48.8	Fair
ELIPH	TN	SUMMER1	0.5660	46.5	Fair	0.6310	60.0	Poor
ELIPH	TN	SUMMER2	0.6880	68.6	Poor	0.6390	55.9	Fair
ELIPH	DIN	ANNUAL	0.1283	54.6	Fair	0.1040	46.6	Fair
ELIPH	DIN	SPRING1	0.1870	83.8	Poor	0.1365	73.0	Poor
ELIPH	DIN	SPRING2	0.1820	80.6	Poor	0.1000	59.0	Fair
ELIPH	DIN	SUMMER1	0.1985	77.9	Poor	0.2295	82.7	Poor
ELIPH	DIN	SUMMER2	0.2613	83.3	Poor	0.2310	80.3	Poor
ELIPH	TP	ANNUAL	0.0540	46.7	Fair	0.0660	56.0	Fair
ELIPH	TP	SPRING1	0.0480	55.9	Fair	0.0600	60.1	Poor
ELIPH	TP	SPRING2	0.0513	60.5	Fair	0.0677	72.3	Poor
ELIPH	TP	SUMMER1	0.0913	77.9	Poor	0.1025	80.9	Poor
ELIPH	TP	SUMMER2	0.1068	85.5	Poor	0.1096	81.5	Poor
ELIPH	PO4F	ANNUAL	0.0200	57.9	Fair	0.0230	64.3	Poor
ELIPH	PO4F	SPRING1	0.0130	72.8	Poor	0.0135	68.3	Poor
ELIPH	PO4F	SPRING2	0.0130	57.8	Fair	0.0160	65.7	Poor
ELIPH	PO4F	SUMMER1	0.0441	81.1	Poor	0.0445	80.1	Poor
ELIPH	PO4F	SUMMER2	0.0680	91.6	Poor	0.0590	89.7	Poor
ELIPH	CHLA	ANNUAL	8.9450	57.9	Fair	-	-	-
ELIPH	CHLA	SPRING1	8.6900	30.2	Good	-	-	-
ELIPH	CHLA	SPRING2	8.6900	45.5	Fair	-	-	-
ELIPH	CHLA	SUMMER1	8.9875	66.7	Poor	-	-	-
ELIPH	CHLA	SUMMER2	7.9400	62.0	Poor	-	-	-
ELIPH	TSS	ANNUAL	9.0000	44.8	Fair	15.5000	36.0	Good
ELIPH	TSS	SPRING1	11.0000	46.2	Fair	33.0000	76.9	Poor
ELIPH	TSS	SPRING2	12.0000	53.7	Fair	29.0000	61.9	Poor
ELIPH	TSS	SUMMER1	10.0000	40.7	Fair	18.0000	30.3	Good
ELIPH	TSS	SUMMER2	9.5000	34.5	Good	16.0000	23.5	Good
ELIPH	SECCHI	ANNUAL	1.0500	31.7	Poor	-	-	-
ELIPH	SECCHI	SPRING1	0.9000	30.2	Poor	-	-	-
ELIPH	SECCHI	SPRING2	0.9000	28.9	Poor	-	-	-
ELIPH	SECCHI	SUMMER1	0.8500	11.5	Poor	-	-	-
ELIPH	SECCHI	SUMMER2	0.8000	4.0	Poor	-	-	-
ELIPH	DO	SPRING1	-	-	-	7.7700	-	Good
ELIPH	DO	SPRING2	-	-	-	6.2400	-	Good
ELIPH	DO	SUMMER1	-	-	-	5.8050	-	Good
ELIPH	DO	SUMMER2	-	-	-	5.9700	-	Good

Table 3-27. Water quality trends in segment ELIPH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
ELIPH	S	TN	0.2685	0.0075	0.4274	-0.0049	0.0557	No Sign. Dif.	0.7685	NS
ELIPH	B	TN	0.0000	0.0000	0.4564	-0.0043	0.4423	No Sign. Dif.	0.4423	NS
ELIPH	S	DIN	0.0997	0.0077	0.7186	0.0024	0.2647	No Sign. Dif.	0.0559	NS
ELIPH	B	DIN	0.1734	0.0080	0.4280	-0.0043	0.0543	No Sign. Dif.	0.7917	NS
ELIPH	S	TP	0.0001	0.0025	0.8254	-0.0001	0.0001	Sign. Dif.	0.0006	-
ELIPH	B	TP	0.0057	0.0025	0.5079	-0.0010	0.0012	Sign. Dif.	0.0605	-
ELIPH	S	PO4F	0.0145	0.0000	0.0426	0.0008	0.9128	No Sign. Dif.	0.0000	**Degrading**
ELIPH	B	PO4F	0.0542	0.0000	0.0409	0.0010	0.7178	No Sign. Dif.	0.0002	**Degrading**

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	p value	Direction
ELIPH	DO	B	Summer1	5.300	0.2000	67.925	0.00	0.0117	**Improving**
ELIPH	SALINITY	S	Annual	21.000	0.6667	57.146	0.00	0.0000	**Increasing**
ELIPH	WTEMP	S	Annual	20.350	0.1829	16.178	0.00	0.0402	**Increasing**
ELIPH	WTEMP	B	Annual	18.500	0.2400	23.351	0.00	0.0326	**Increasing**

Table 3-28. SAV season water quality status in segment ELIPH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
ELIPH	DIN	SAV2	0.182	66	Poor	Fails
ELIPH	PO4F	SAV2	0.023	62.6	Fair	Fails
ELIPH	CHLA	SAV2	7.18	51.8	Fair	Meets
ELIPH	TSS	SAV2	9	42.8	Fair	Meets
ELIPH	SECCHI	SAV2	1.1	35.9	Poor	Meets

Table 3-29. SAV Season Water quality trends in segment ELIPH (only significant trends are displayed).

a) Nutrient parameters

Segment	Layer	Parameter	'93 Trend p value	'93 Slope	'02 Trend p value	'02 Slope	Trend Comparison p value	Trend Comparison	Combined Trend p value	Combined Trend Direction
ELIPH	S	TN	0.1562	0.0142	0.5814	0.0084	0.40905	No Sign. Dif.	0.05823	NS
ELIPH	S	DIN	0.1227	0.0107	0.5003	0.0051	0.46860	No Sign. Dif.	0.03838	Degrading
ELIPH	S	TP	0.0056	0.0025	0.1931	-0.0011	0.00020	Sign. Dif.	0.20436	-
ELIPH	S	PO4F	0.0815	0.0000	0.1271	0.0010	0.96118	No Sign. Dif.	0.00299	Degrading

b) Non nutrient parameters

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	p value	Direction
ELIPH	SALINITY	S	SAV2	16.80	0.4083	34.0	0.00	0.0176	Increasing

Table 3-30. Water quality status in segment ELIMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
ELIMH	TN	ANNUAL	0.6498	48.5	Fair	0.5719	26.5	Good
ELIMH	TN	SPRING1	0.6252	37.0	Good	0.5677	19.4	Good
ELIMH	TN	SPRING2	0.6670	55.9	Fair	0.5677	22.2	Good
ELIMH	TN	SUMMER1	0.7400	72.9	Poor	0.6683	47.0	Fair
ELIMH	TN	SUMMER2	0.7566	75.5	Poor	0.7286	62.2	Poor
ELIMH	DIN	ANNUAL	0.1348	58.9	Fair	0.1318	57.5	Fair
ELIMH	DIN	SPRING1	0.1459	53.4	Fair	0.1297	51.6	Fair
ELIMH	DIN	SPRING2	0.1459	64.9	Poor	0.1383	61.4	Poor
ELIMH	DIN	SUMMER1	0.2352	92.0	Poor	0.2212	89.8	Poor
ELIMH	DIN	SUMMER2	0.3158	96.2	Poor	0.2849	96.3	Poor
ELIMH	TP	ANNUAL	0.0533	63.4	Fair	0.0590	58.8	Fair
ELIMH	TP	SPRING1	0.0502	57.5	Fair	0.0558	54.3	Fair
ELIMH	TP	SPRING2	0.0527	60.0	Fair	0.0611	53.7	Fair
ELIMH	TP	SUMMER1	0.0830	84.0	Poor	0.0893	75.1	Poor
ELIMH	TP	SUMMER2	0.1021	90.9	Poor	0.1002	82.5	Poor
ELIMH	PO4F	ANNUAL	0.0133	69.1	Poor	0.0225	84.6	Poor
ELIMH	PO4F	SPRING1	0.0055	36.0	Good	0.0091	62.2	Poor
ELIMH	PO4F	SPRING2	0.0090	56.5	Fair	0.0145	76.6	Poor
ELIMH	PO4F	SUMMER1	0.0448	93.0	Poor	0.0432	91.8	Poor
ELIMH	PO4F	SUMMER2	0.0545	93.7	Poor	0.0586	93.9	Poor
ELIMH	CHLA	ANNUAL	10.0392	60.0	Poor	-	-	-
ELIMH	CHLA	SPRING1	11.4810	50.9	Fair	-	-	-
ELIMH	CHLA	SPRING2	11.0360	57.2	Fair	-	-	-
ELIMH	CHLA	SUMMER1	7.4760	33.7	Good	-	-	-
ELIMH	CHLA	SUMMER2	6.8085	28.0	Good	-	-	-
ELIMH	TSS	ANNUAL	13.1625	55.1	Fair	17.3600	44.1	Fair
ELIMH	TSS	SPRING1	14.6400	52.4	Fair	27.7333	62.5	Poor
ELIMH	TSS	SPRING2	15.5000	53.5	Fair	22.3250	43.2	Fair
ELIMH	TSS	SUMMER1	13.5600	47.9	Fair	18.7292	37.7	Good
ELIMH	TSS	SUMMER2	13.3000	44.4	Fair	18.4250	38.9	Good
ELIMH	SECCHI	ANNUAL	1.0000	49.9	Fair	-	-	-
ELIMH	SECCHI	SPRING1	0.9000	53.5	Fair	-	-	-
ELIMH	SECCHI	SPRING2	0.7000	37.7	Fair	-	-	-
ELIMH	SECCHI	SUMMER1	0.9000	49.7	Fair	-	-	-
ELIMH	SECCHI	SUMMER2	0.9000	47.4	Fair	-	-	-
ELIMH	DO	SPRING1	-	-	-	7.9500	-	Good
ELIMH	DO	SPRING2	-	-	-	6.9500	-	Good
ELIMH	DO	SUMMER1	-	-	-	5.7250	-	Good
ELIMH	DO	SUMMER2	-	-	-	5.8210	-	Good

Table 3-31. Water quality trends in segment ELIMH (only significant trends are displayed).

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
ELIMH	TN	S	Annual	0.710	-0.0071	-14.00	0.00	0.0448	Improving
ELIMH	DIN	S	Annual	0.358	-0.0079	-30.86	3.01	0.0001	Improving
ELIMH	DIN	B	Annual	0.216	-0.0068	-44.09	0.61	0.0002	Improving
ELIMH	TP	S	Annual	0.063	-0.0013	-28.48	0.00	0.0000	Improving
ELIMH	TP	B	Annual	0.069	-0.0011	-21.30	0.00	0.0008	Improving
ELIMH	PO4F	S	Annual	0.038	-0.0007	-26.44	10.91	0.0000	Improving
ELIMH	PO4F	B	Annual	0.030	-0.0009	-42.84	9.82	0.0000	Improving
ELIMH	DO	B	Summer1	4.10	0.1322	45.15	0.00	0.0007	Improving
ELIMH	WTEMP	S	Annual	15.75	0.1086	9.65	0.00	0.0033	Increasing
ELIMH	WTEMP	B	Annual	14.95	0.1742	16.31	0.00	0.0002	Increasing
ELIMH	SALINITY	S	Annual	16.80	0.2630	21.92	0.00	0.0000	Increasing

Table 3-32. SAV season water quality status in segment ELIMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
ELIMH	DIN	SAV1	0.1731	79	**Poor**	**Fails**
ELIMH	PO4F	SAV1	0.0182	72.8	**Poor**	**Fails**
ELIMH	CHLA	SAV1	6.764	29.2	**Good**	**Meets**
ELIMH	TSS	SAV1	13.1625	45.7	**Fair**	**Meets**
ELIMH	SECCHI	SAV1	1	56.3	**Fair**	**Meets**

Table 3-33. SAV Season Water quality trends in segment ELIMH (only significant trends are displayed).

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
ELIMH	S	SAV1	DIN	0.341	-0.0073	-30.12	0.0092	4.12	**Improving**
ELIMH	S	SAV1	WTEMP	23.40	0.1200	7.18	0.0073	0.00	**Increasing**
ELIMH	S	SAV1	SALINITY	17.15	0.2545	20.78	0.0001	0.00	**Increasing**

Table 3-34. Water quality status in segment WBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
WBEMH	TN	ANNUAL	0.6388	46.0	Fair	0.6293	39.2	Good
WBEMH	TN	SPRING1	0.5691	26.3	Good	0.6008	25.2	Good
WBEMH	TN	SPRING2	0.6417	49.8	Fair	0.6375	37.9	Good
WBEMH	TN	SUMMER1	0.7722	79.2	Poor	0.8098	78.9	Poor
WBEMH	TN	SUMMER2	0.7938	82.4	Poor	0.8255	81.3	Poor
WBEMH	DIN	ANNUAL	0.0911	40.1	Good	0.1101	47.4	Fair
WBEMH	DIN	SPRING1	0.0753	24.2	Good	0.0844	30.1	Good
WBEMH	DIN	SPRING2	0.0286	6.3	Good	0.0769	30.2	Good
WBEMH	DIN	SUMMER1	0.1845	87.4	Poor	0.1913	86.8	Poor
WBEMH	DIN	SUMMER2	0.1968	90.0	Poor	0.2110	91.9	Poor
WBEMH	TP	ANNUAL	0.0627	73.3	Poor	0.0630	63.0	Poor
WBEMH	TP	SPRING1	0.0606	68.8	Poor	0.0577	56.2	Fair
WBEMH	TP	SPRING2	0.0608	69.8	Poor	0.0636	56.3	Fair
WBEMH	TP	SUMMER1	0.0996	91.3	Poor	0.1121	86.8	Poor
WBEMH	TP	SUMMER2	0.0999	90.1	Poor	0.1157	88.6	Poor
WBEMH	PO4F	ANNUAL	0.0104	58.9	Fair	0.0134	68.0	Poor
WBEMH	PO4F	SPRING1	0.0044	26.0	Good	0.0041	21.2	Good
WBEMH	PO4F	SPRING2	0.0047	26.1	Good	0.0041	17.8	Good
WBEMH	PO4F	SUMMER1	0.0372	90.6	Poor	0.0375	89.6	Poor
WBEMH	PO4F	SUMMER2	0.0452	91.6	Poor	0.0450	90.6	Poor
WBEMH	CHLA	ANNUAL	11.3920	67.8	Poor	-	-	-
WBEMH	CHLA	SPRING1	12.8160	57.5	Fair	-	-	-
WBEMH	CHLA	SPRING2	15.3080	78.0	Poor	-	-	-
WBEMH	CHLA	SUMMER1	15.0410	84.9	Poor	-	-	-
WBEMH	CHLA	SUMMER2	12.8160	76.2	Poor	-	-	-
WBEMH	TSS	ANNUAL	21.7750	77.3	Poor	27.1500	66.8	Poor
WBEMH	TSS	SPRING1	26.5000	78.1	Poor	30.9800	67.0	Poor
WBEMH	TSS	SPRING2	26.5000	76.6	Poor	34.5000	63.6	Poor
WBEMH	TSS	SUMMER1	30.8459	85.9	Poor	41.5584	78.0	Poor
WBEMH	TSS	SUMMER2	31.0667	87.5	Poor	51.5500	87.3	Poor
WBEMH	SECCHI	ANNUAL	0.7000	26.9	Poor	-	-	-
WBEMH	SECCHI	SPRING1	0.6000	30.3	Poor	-	-	-
WBEMH	SECCHI	SPRING2	0.5000	20.3	Poor	-	-	-
WBEMH	SECCHI	SUMMER1	0.5000	10.1	Poor	-	-	-
WBEMH	SECCHI	SUMMER2	0.5000	8.2	Poor	-	-	-
WBEMH	DO	SPRING1	-	-	-	8.3900	-	Good
WBEMH	DO	SPRING2	-	-	-	7.8000	-	Good
WBEMH	DO	SUMMER1	-	-	-	5.7655	-	Good
WBEMH	DO	SUMMER2	-	-	-	5.7450	-	Good

Table 3-35. Water quality trends in segment WBEMH (only significant trends are displayed).

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
WBEMH	TN	S	Annual	0.800	-0.0140	-24.48	0.00	0.0000	**Improving**
WBEMH	TN	B	Annual	0.791	-0.0104	-18.38	0.00	0.0007	**Improving**
WBEMH	DIN	S	Annual	0.198	-0.0039	-27.61	12.20	0.0040	**Improving**
WBEMH	DIN	B	Annual	0.257	-0.0063	-34.26	7.32	0.0046	**Improving**
WBEMH	TP	S	Annual	0.083	-0.0020	-33.73	0.00	0.0000	**Improving**
WBEMH	TP	B	Annual	0.080	-0.0017	-29.12	0.00	0.0001	**Improving**
WBEMH	PO4F	S	Annual	0.035	-0.0008	-30.43	14.11	0.0000	**Improving**
WBEMH	PO4F	B	Annual	0.033	-0.0009	-36.59	13.41	0.0000	**Improving**
WBEMH	CHLA	S	Annual	23.00	-0.4667	-28.41	2.50	0.0086	**Improving**
WBEMH	SECCHI	S	Annual	0.60	0.0000	0.00	0.00	0.0133	**Improving**
WBEMH	DO	B	Summer1	4.40	0.1096	34.86	0.00	0.0290	**Improving**
WBEMH	SALINITY	S	Annual	15.90	0.2660	23.42	0.00	0.0000	**Increasing**
WBEMH	SALINITY	B	Annual	16.70	0.2300	19.28	0.00	0.0002	**Increasing**

Table 3-36. SAV season water quality status in segment WBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
WBEMH	DIN	SAV1	0.1576	75.6	**Poor**	**Fails**
WBEMH	PO4F	SAV1	0.0274	86.2	**Poor**	**Fails**
WBEMH	CHLA	SAV1	12.816	75.3	**Poor**	**Meets**
WBEMH	TSS	SAV1	29.1143	82.7	**Poor**	**Fails**
WBEMH	SECCHI	SAV1	0.5	13.4	**Poor**	**Fails**

Table 3-37. SAV Season Water quality trends in segment WBEMH (only significant trends are displayed).

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
WBEMH	S	SAV1	TN	0.813	-0.0107	-18.36	0.0031	0.00	**Improving**
WBEMH	S	SAV1	TP	0.110	-0.0022	-28.43	0.0002	0.00	**Improving**
WBEMH	S	SAV1	PO4F	0.051	-0.0011	-30.73	0.0000	6.32	**Improving**
WBEMH	S	SAV1	SALINITY	17.15	0.2600	21.22	0.0005	0.00	**Increasing**

Table 3-38. **Water quality status in segment SBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).**

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
SBEMH	TN	ANNUAL	0.9652	88.7	**Poor**	0.8734	82.1	**Poor**
SBEMH	TN	SPRING1	0.9620	79.7	**Poor**	0.8540	68.5	**Poor**
SBEMH	TN	SPRING2	0.8920	88.9	**Poor**	0.8540	78.7	**Poor**
SBEMH	TN	SUMMER1	1.0110	96.4	**Poor**	0.9661	92.9	**Poor**
SBEMH	TN	SUMMER2	1.0114	97.1	**Poor**	0.9647	91.9	**Poor**
SBEMH	DIN	ANNUAL	0.4316	92.3	**Poor**	0.3730	93.2	**Poor**
SBEMH	DIN	SPRING1	0.3547	87.0	**Poor**	0.3221	89.5	**Poor**
SBEMH	DIN	SPRING2	0.3509	91.7	**Poor**	0.3038	92.2	**Poor**
SBEMH	DIN	SUMMER1	0.4541	98.1	**Poor**	0.4236	98.2	**Poor**
SBEMH	DIN	SUMMER2	0.4672	98.4	**Poor**	0.4814	99.1	**Poor**
SBEMH	TP	ANNUAL	0.0572	64.8	**Poor**	0.0616	58.5	**Fair**
SBEMH	TP	SPRING1	0.0472	50.6	**Fair**	0.0456	44.4	**Fair**
SBEMH	TP	SPRING2	0.0474	52.5	**Fair**	0.0583	48.9	**Fair**
SBEMH	TP	SUMMER1	0.1019	93.3	**Poor**	0.1145	87.2	**Poor**
SBEMH	TP	SUMMER2	0.1143	93.8	**Poor**	0.1229	90.5	**Poor**
SBEMH	PO4F	ANNUAL	0.0268	87.7	**Poor**	0.0274	89.2	**Poor**
SBEMH	PO4F	SPRING1	0.0188	86.2	**Poor**	0.0177	84.0	**Poor**
SBEMH	PO4F	SPRING2	0.0142	76.5	**Poor**	0.0196	85.6	**Poor**
SBEMH	PO4F	SUMMER1	0.0632	95.3	**Poor**	0.0717	96.4	**Poor**
SBEMH	PO4F	SUMMER2	0.0748	95.1	**Poor**	0.0758	96.5	**Poor**
SBEMH	CHLA	ANNUAL	4.8416	16.2	**Good**	-	-	-
SBEMH	CHLA	SPRING1	4.4322	10.1	**Good**	-	-	-
SBEMH	CHLA	SPRING2	6.0075	14.8	**Good**	-	-	-
SBEMH	CHLA	SUMMER1	7.3759	29.6	**Good**	-	-	-
SBEMH	CHLA	SUMMER2	5.6070	20.0	**Good**	-	-	-
SBEMH	TSS	ANNUAL	9.3500	35.0	**Good**	11.2113	25.3	**Good**
SBEMH	TSS	SPRING1	10.1100	32.5	**Good**	12.7934	26.6	**Good**
SBEMH	TSS	SPRING2	11.0000	33.5	**Good**	16.3750	23.0	**Good**
SBEMH	TSS	SUMMER1	10.0700	29.7	**Good**	14.4588	25.3	**Good**
SBEMH	TSS	SUMMER2	9.7900	26.1	**Good**	13.6775	26.5	**Good**
SBEMH	SECCHI	ANNUAL	1.1750	62.4	**Good**	-	-	-
SBEMH	SECCHI	SPRING1	1.2500	65.1	**Good**	-	-	-
SBEMH	SECCHI	SPRING2	1.1500	60.2	**Good**	-	-	-
SBEMH	SECCHI	SUMMER1	1.0500	59.3	**Good**	-	-	-
SBEMH	SECCHI	SUMMER2	1.1000	57.8	**Good**	-	-	-
SBEMH	DO	SPRING1	-	-	-	7.5700	-	**Good**
SBEMH	DO	SPRING2	-	-	-	6.3800	-	**Good**
SBEMH	DO	SUMMER1	-	-	-	4.5165	-	**Fair**
SBEMH	DO	SUMMER2	-	-	-	4.4730	-	**Fair**

Table 3-39. Water quality trends in segment SBEMH (only significant trends are displayed).

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
SBEMH	TN	S	Annual	1.333	-0.0256	-26.91	0.00	0.0000	Improving
SBEMH	DIN	S	Annual	0.738	-0.0199	-37.76	0.00	0.0000	Improving
SBEMH	DIN	B	Annual	0.586	-0.0077	-18.52	0.00	0.0189	Improving
SBEMH	TP	S	Annual	0.074	-0.0015	-28.16	0.00	0.0000	Improving
SBEMH	TP	B	Annual	0.079	-0.0018	-31.85	0.00	0.0000	Improving
SBEMH	PO4F	S	Annual	0.048	-0.0009	-26.39	3.34	0.0008	Improving
SBEMH	PO4F	B	Annual	0.048	-0.0013	-37.38	5.47	0.0000	Improving
SBEMH	CHLA	B	Annual	3.35	0.0939	39.24	27.24	0.0173	Degrading
SBEMH	TSS	S	Annual	8.58	-0.1718	-28.06	0.00	0.0416	Improving
SBEMH	TSS	B	Annual	13.08	-0.4083	-43.71	0.00	0.0024	Improving
SBEMH	SECCHI	S	Annual	0.75	0.0167	31.11	0.00	0.0027	Improving
SBEMH	DO	B	Summer1	2.65	0.1186	62.64	0.00	0.0045	Improving
SBEMH	WTEMP	S	Annual	18.20	0.1500	11.54	0.00	0.0003	Increasing
SBEMH	WTEMP	B	Annual	17.10	0.2767	22.65	0.00	0.0000	Increasing
SBEMH	SALINITY	S	Annual	14.75	0.2931	27.82	0.00	0.0000	Increasing

Table 3-40. SAV season water quality status in segment SBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
SBEMH	DIN	SAV1	0.4192	95.8	**Poor**	**Fails**
SBEMH	PO4F	SAV1	0.0356	90.8	**Poor**	**Fails**
SBEMH	CHLA	SAV1	5.34	14.9	**Good**	**Meets**
SBEMH	TSS	SAV1	10.11	30	**Good**	**Meets**
SBEMH	SECCHI	SAV1	1.15	63.3	**Good**	**Meets**

Table 3-41. SAV Season Water quality trends in segment SBEMH (only significant trends are displayed).

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
SBEMH	S	SAV1	TN	1.266	-0.0163	-17.98	0.0040	0.00	**Improving**
SBEMH	S	SAV1	DIN	0.702	-0.0155	-31.01	0.0031	0.00	**Improving**
SBEMH	S	SAV1	TP	0.100	-0.0013	-18.29	0.0064	0.00	**Improving**
SBEMH	S	SAV1	PO4F	0.067	-0.0010	-20.82	0.0274	2.07	**Improving**
SBEMH	S	SAV1	SECCHI	0.75	0.0200	37.33	0.0052	0.00	**Improving**
SBEMH	S	SAV1	WTEMP	25.20	0.1522	8.46	0.0029	0.00	**Increasing**
SBEMH	S	SAV1	SALINITY	16.70	0.2932	24.58	0.0001	0.00	**Increasing**

Table 3-42. Water quality status in segment EBEMH (value is the median concentration, secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Svalue	Sscore	Sstatus	Bvalue	Bscore	Bstatus
EBEMH	TN	ANNUAL	0.7230	63.8	Poor	0.6736	49.4	Fair
EBEMH	TN	SPRING1	0.7063	52.7	Fair	0.6067	26.1	Good
EBEMH	TN	SPRING2	0.7230	67.9	Poor	0.6880	50.0	Fair
EBEMH	TN	SUMMER1	0.7860	81.5	Poor	0.8043	78.1	Poor
EBEMH	TN	SUMMER2	0.8055	83.9	Poor	0.8296	81.6	Poor
EBEMH	DIN	ANNUAL	0.2710	84.7	Poor	0.2119	79.8	Poor
EBEMH	DIN	SPRING1	0.2261	72.8	Poor	0.2125	75.0	Poor
EBEMH	DIN	SPRING2	0.2215	81.2	Poor	0.2125	80.5	Poor
EBEMH	DIN	SUMMER1	0.3503	96.6	Poor	0.3079	95.8	Poor
EBEMH	DIN	SUMMER2	0.4155	97.9	Poor	0.3995	98.5	Poor
EBEMH	TP	ANNUAL	0.0526	62.6	Poor	0.0521	50.5	Fair
EBEMH	TP	SPRING1	0.0438	48.8	Fair	0.0440	40.1	Good
EBEMH	TP	SPRING2	0.0536	61.2	Poor	0.0492	39.4	Good
EBEMH	TP	SUMMER1	0.0882	86.9	Poor	0.1053	84.2	Poor
EBEMH	TP	SUMMER2	0.1062	90.2	Poor	0.1135	87.5	Poor
EBEMH	PO4F	ANNUAL	0.0204	82.9	Poor	0.0223	84.4	Poor
EBEMH	PO4F	SPRING1	0.0132	78.1	Poor	0.0120	75.5	Poor
EBEMH	PO4F	SPRING2	0.0132	73.7	Poor	0.0182	84.3	Poor
EBEMH	PO4F	SUMMER1	0.0565	95.3	Poor	0.0579	95.1	Poor
EBEMH	PO4F	SUMMER2	0.0722	95.6	Poor	0.0745	95.5	Poor
EBEMH	CHLA	ANNUAL	6.3546	30.9	Good	-	-	-
EBEMH	CHLA	SPRING1	6.6216	21.5	Good	-	-	-
EBEMH	CHLA	SPRING2	9.6254	45.0	Fair	-	-	-
EBEMH	CHLA	SUMMER1	4.6725	9.2	Good	-	-	-
EBEMH	CHLA	SUMMER2	4.2720	7.7	Good	-	-	-
EBEMH	TSS	ANNUAL	11.0800	46.3	Fair	15.1750	37.3	Good
EBEMH	TSS	SPRING1	11.4250	40.2	Good	15.2800	36.5	Good
EBEMH	TSS	SPRING2	11.3800	38.7	Good	15.3750	27.1	Good
EBEMH	TSS	SUMMER1	11.0800	36.7	Good	15.7000	29.0	Good
EBEMH	TSS	SUMMER2	11.0200	33.1	Good	15.5400	30.0	Good
EBEMH	SECCHI	ANNUAL	1.1000	56.6	Fair	-	-	-
EBEMH	SECCHI	SPRING1	1.1000	65.1	Good	-	-	-
EBEMH	SECCHI	SPRING2	1.0000	60.2	Good	-	-	-
EBEMH	SECCHI	SUMMER1	1.0000	59.3	Good	-	-	-
EBEMH	SECCHI	SUMMER2	1.0500	62.2	Good	-	-	-
EBEMH	DO	SPRING1	-	-	-	7.9400	.	Good
EBEMH	DO	SPRING2	-	-	-	7.3200	.	Good
EBEMH	DO	SUMMER1	-	-	-	4.9300	.	Fair
EBEMH	DO	SUMMER2	-	-	-	4.9800	.	Fair

Table 3-43. Water quality trends in segment EBEMH (only significant trends are displayed).

Segment	Parameter	Layer	Season	Baseline	Slope	% Change	% BDL	pValue	Direction
EBEMH	TN	S	Annual	1.040	-0.0161	-21.65	0.00	0.0003	**Improving**
EBEMH	TN	B	Annual	0.855	-0.0137	-22.51	0.00	0.0000	**Improving**
EBEMH	DIN	S	Annual	0.507	-0.0136	-37.66	0.00	0.0005	**Improving**
EBEMH	DIN	B	Annual	0.490	-0.0139	-39.73	0.00	0.0000	**Improving**
EBEMH	TP	S	Annual	0.075	-0.0018	-33.12	0.00	0.0000	**Improving**
EBEMH	TP	B	Annual	0.074	-0.0017	-31.53	0.00	0.0000	**Improving**
EBEMH	PO4F	S	Annual	0.044	-0.0009	-27.36	8.75	0.0002	**Improving**
EBEMH	PO4F	B	Annual	0.046	-0.0010	-30.77	8.70	0.0000	**Improving**
EBEMH	SECCHI	S	Annual	1.00	0.0111	15.56	0.00	0.0185	**Improving**
EBEMH	DO	B	Summer1	3.25	0.1000	43.08	0.00	0.0175	**Improving**
EBEMH	WTEMP	S	Annual	17.00	0.0750	6.18	0.00	0.0482	**Increasing**
EBEMH	WTEMP	B	Annual	15.90	0.1345	11.84	0.00	0.0009	**Increasing**
EBEMH	SALINITY	S	Annual	16.85	0.2253	18.72	0.00	0.0000	**Increasing**
EBEMH	SALINITY	B	Annual	18.40	0.1456	11.08	0.00	0.0295	**Increasing**

Table 3-44. SAV season water quality status in segment EBEMH (value is the median concentration; secchi depth in meters, chlorophyll *a* in µg/l, all other parameters in mg/l).

Segment	Parameter	Season	Value	Score	Status	Habitat Requirement
EBEMH	DIN	SAV1	0.2923	91.9	**Poor**	**Fails**
EBEMH	PO4F	SAV1	0.0352	90.7	**Poor**	**Fails**
EBEMH	CHLA	SAV1	5.9096	21	**Good**	**Meets**
EBEMH	TSS	SAV1	11.24	37.3	**Good**	**Meets**
EBEMH	SECCHI	SAV1	1.1	63.3	**Good**	**Meets**

Table 3-45. SAV Season Water quality trends in segment EBEMH (only significant trends are displayed).

Segment	Layer	Season	Parameter	Baseline	Slope	% Change	p value	%BDL	Direction
EBEMH	S	SAV1	DIN	0.530	-0.0137	-36.10	0.0039	0.00	**Improving**
EBEMH	S	SAV1	TP	0.086	-0.0012	-20.35	0.0293	0.00	**Improving**
EBEMH	S	SAV1	SALINITY	17.95	0.2180	17.00	0.0004	0.00	**Increasing**

Literature Cited

Alden, R.W. III., R.S. Birdsong, D.M. Dauer, H.G. Marshall and R.M. Ewing, 1992a. Virginia Chesapeake Bay water quality and living resources monitoring programs: Comprehensive technical report, 1985-1989. Applied Marine Research Laboratory Technical Report No. 848, Norfolk VA. Final Report to the Virginia State Water Control Board, Richmond, Virginia.

Alden, R.W. III, D.M. Dauer, J.A. Ranasinghe, L.C. Scott, and R.J. Llansó. 2002. Statistical verification of the Chesapeake Bay Benthic Index of Biotic Integrity. *Environmetrics* 13: 473- 498.

Alden, R.W. III., R.M. Ewing, S.W. Sokolowski, J.C. Seibel, 1991. Long-term trends in water quality of the Lower Chesapeake Bay. p. 502-522, In: New Perspectives in the Chesapeake System: A Research and Management Partnership. Proceedings of a Conference. Chesapeake Research Consortium Publication No. 137, Solomons, MD., pp. 780.

Alden, R.W. III. and M.F. Lane, 1996. An assessment of the power and robustness of the Chesapeake Bay Program Water Quality Monitoring Programs: Phase III - Refinement evaluations. Applied Marine Research Laboratory Technical Report No. 3002, Norfolk VA. Final Report to the Virginia State Water Control Board, Richmond, Virginia.

Alden, R.W. III., M.F. Lane, H. Lakkis, J.C. Seibel, 1992b. An assessment of the power and robustness of the Chesapeake Bay Program Water Quality Monitoring Programs: Phase I - Preliminary evaluations. Applied Marine Research Laboratory Technical Report No. 846, Norfolk VA. Final Report to the Virginia State Water Control Board, Richmond, Virginia.

Alden, R.W. III., M.F. Lane, H. Lakkis, J.C. Seibel, 1994. An assessment of the power and robustness of the Chesapeake Bay Program Water Quality Monitoring Programs: Phase II - Refinement evaluations. Applied Marine Research Laboratory Technical Report No. 965, Norfolk VA. Final Report to the Virginia State Water Control Board, Richmond, Virginia.

Alden, R.W. III, S.B. Weisberg, J.A. Ranasinghe and D.M. Dauer. 1997. Optimizing temporal sampling strategies for benthic environmental monitoring programs. *Marine Pollution Bulletin* 34: 913-922.

Batuik, R.A., R.J. Orth, K.A. Moore, W.C. Dennison, J.C. Stevenson, L.W. Staver, V. Carter, N.B. Rybicki, R.E. Hickman, S. Kollar, S. Beiber, and P. Heasly, 1992. Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis. CBP/TRS83/92. US Environmental Protection Agency Chesapeake Bay Program. Annapolis, MD., pp. 186.

Batuik, R.A., P. Bergstrom, M. Kemp, E. Koch, L. Murray, J.C. Stevenson, R. Bartleson, V. Carter, N.B. Rybicki, J.M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K.A. Moore, S. Ailstock, and M. Teichberg, 2000. Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Second Technical Synthesis. US Environmental Protection Agency Chesapeake Bay Program, pp. 217.

Carpenter, K.E. and M.F. Lane, 1998. Zooplankton Status and Trends in the Virginia Tributaries and Chesapeake Bay: 1985-1996. AMRL Technical Report No. 3064. Final Report to the Virginia Department of Environmental Quality, Richmond, Virginia. Applied Marine Research Laboratory, Norfolk VA., pp. 28.

Dauer, D.M., 1993. Biological criteria, environmental health and estuarine macrobenthic community structure. *Mar. Pollut. Bull.* 26: 249-257.

Dauer, D.M. 1997. Virginia Chesapeake Bay Monitoring Program. Benthic Communities Report. 1985-1996. Final Report to the Virginia Department of Environmental Quality, pp. 92.

Dauer, D.M. 1999. Baywide benthic community condition based upon 1997 random probability based sampling and relationships between benthic community condition, water quality, sediment quality, nutrient loads and land use patterns in Chesapeake Bay. Final report to the Virginia Department of Environmental Quality, pp.18.

Dauer, D.M., M. F. Lane, H.G. Marshall, and K.E. Carpenter. 1998a. Status and trends in water quality and living resources in the Virginia Chesapeake Bay: 1985-1997. Final report to the Virginia Department of Environmental Quality, pp. 86.

Dauer, D.M., M. F. Lane, H.G. Marshall, K.E. Carpenter and J.R. Donat. 2002. Status and trends in water quality and living resources in the Virginia Chesapeake Bay: 1985-2000. Final report to the Virginia Department of Environmental Quality, pp. 149.

Dauer, D.M., Luckenbach, M.W. and A.J. Rodi, Jr., 1993. Abundance biomass comparison (ABC method):effects of an estuarine gradient, anoxic/hypoxic events and contaminated sediments. *Mar. Biol.* 116: 507-518.

Dauer, D.M., H.G. Marshall, K.E. Carpenter, M.F. Lane, R.W. Alden III, K.K. Nesius and L.W. Haas, 1998b. Virginia Chesapeake Bay Water Quality and Living Resources Monitoring Programs: Executive Report, 1985-1996. Final Report to the Virginia Department of Environmental Quality, Richmond, Virginia. Applied Marine Research Laboratory, Norfolk VA., pp. 28.

Dauer, D.M. and A.J. Rodi, Jr. 1998a. Benthic biological monitoring of the lower Chesapeake Bay. 1996 Random Sampling. Virginia Department of Environmental Quality, Chesapeake Bay Program, pp. 137.

Dauer, D.M. and A.J. Rodi, Jr. 1998b. Benthic biological monitoring of the lower Chesapeake Bay. 1997 Random Sampling. Virginia Department of Environmental Quality, Chesapeake Bay Program, pp. 132.

Dauer, D.M. and A.J. Rodi, Jr. 1999. Baywide benthic community condition based upon 1998 random probability based sampling. Final report to the Virginia Department of Environmental Quality, pp. 126.

Dauer, D.M. and A.J. Rodi, Jr. 2001. Baywide benthic community condition based upon 1999 random probability based sampling. Final report to the Virginia Department of Environmental Quality, pp. 154.

Dauer, D.M. and A.J. Rodi, Jr. 2002. Baywide benthic community condition based upon 2000 random probability based sampling. Final report to the Virginia Department of Environmental Quality, pp. 151.

Dauer, D.M., Rodi, Jr., A.J. and J.A. Ranasinghe, 1992. Effects of low dissolved oxygen events on the macrobenthos of the lower Chesapeake Bay. *Estuaries* 15: 384-391.

Donat, J.R. and S.C. Doughten, 2003. Work/Quality Assurance Project Plan for Chesapeake Bay Mainstem and Elizabeth River Water Quality Monitoring Program. Revision 5. Old Dominion University, Norfolk, VA. Prepared for the Virginia Department of Environmental Quality, Richmond, VA., pp. 469.

Folk, R.L. 1974. Petrology of sedimentary rocks. Hemphill Publishing Co., Austin, Texas, pp. 182.

Gilbert, R.O., 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold Co., New York, pp. 320.

Lane, M.F., R.W. Alden III, and A.W. Messing, 1998. Water Quality Status and Trends in the Virginia Tributaries and Chesapeake Bay: 1985-1996. AMRL Technical Report No. 3067. Final Report to the Virginia Department of Environmental Quality, Richmond, Virginia. Applied Marine Research Laboratory, Norfolk VA., pp. 116.

Margalef, R., 1958. Information theory in ecology. *Gen. Syst*. 3:36-71.

Marshall, H.G. 1994. Chesapeake Bay phytoplankton: I. Composition. *Proc. Biological Soc. Washington*, 107:573-585.

Marshall, H.G. 1995. Succession of dinoflagellate blooms in the Chesapeake Bay, U.S.A. In: P. Lassus et al. (eds.) Harmful Marine Algal Blooms, Lavoisier, Intercept, Ltd., pp. 615-620.

Marshall, H.G. 1996. Toxin producing phytoplankton in Chesapeake Bay. *Virginia J. Science*, 47:29-37.

Marshall, H.G. and R.W. Alden. 1990. A comparison of phytoplankton assemblages and environmental relationships in three estuarine rivers of the lower Chesapeake Bay. *Estuaries*, 13:287-300.

Marshall, H.G. and L. Burchardt. 1998. Phytoplankton composition within the tidal freshwater region of the James River, Virginia. *Proc. Biol Soc. Wash.* 111:720-730.

Marshall, H.G. and K.K. Nesius. 1996. Phytoplankton composition in relation to primary production in Chesapeake Bay. *Marine Biology*, 125:611-617.

Marshall, H.G., K.K. Nesius, and M.F. Lane, 1998. Phytoplankton Status and Trends in the Virginia Tributaries and Chesapeake Bay: 1985-1996. AMRL Technical Report No. 3063. Final Report to the Virginia Department of Environmental Quality, Richmond, Virginia. Applied Marine Research Laboratory, Norfolk VA., pp. 33.

Park, G.S. and H,G. Marshall. 1993. Microzooplankton in the Lower Chesapeake Bay, and the tidal Elizabeth, James, and York Rivers. *Virginia J. Science*, 44:329-340.

Ranasinghe, J.A., S.B. Weisberg, D.M. Dauer, L.C. Schaffner, R.J. Diaz and J.B. Frithsen, 1994. Chesapeake Bay benthic community restoration goals. Report for the U.S. Environmental Protection Agency, Chesapeake Bay Office and the Maryland Department of Natural Resources, pp. 49.

Symposium on the Classification of Brackish Waters, 1958. The Venice system for the classification of marine waters according to salinity. *Oikos* 9:11-12.

Venrick,E.L. 1978. How many cells to count. In: A. Sournia (ed.) Phytoplankton Manual. UNESCO Publ. Page Brothers Ltd., pp. 167-180.

Weisberg, S.B., A.F. Holland, K.J. Scott, H.T. Wilson, D.G. Heimbuch, S.C. Schimmel, J.B. Frithsen, J.F. Paul, J.K. Summers, R.M. Valente, J. Gerritsen, and R.W. Latimer. 1993. EMAP-Estuaries, Virginian Province 1990: Demonstration Project Report. EPA/600/R-92/100. U.S. Environmental Protection Agency, Washington, D.C.

Weisberg, S.B., J.A. Ranasinghe, D.M. Dauer, L.C. Schaffner, R.J. Diaz and J.B. Frithsen, 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. *Estuaries.* 20: 149-158.

Glossary of Important Terms

Anoxic - condition in which the water column is characterized by a complete absence of oxygen. Anoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Anoxic conditions can result in fish kills or localized extinction of benthic communities.

Anthropogenic - resulting from or generated by human activities.

Benthos - refers to organisms that dwell on or within the bottom. Includes both hard substratum habitats (e.g. oyster reefs) and sedimentary habitats (sand and mud bottoms).

B-IBI - the benthic index of biotic integrity of Weisberg et al. (1997). The B-IBI is a multi-metric index that compares the condition of a benthic community to reference conditions.

Biological Nutrient Removal (BNR) - A temperature dependent process in which the ammonia nitrogen present in wastewater is converted by bacteria first to nitrate nitrogen and then to nitrogen gas. This technique is used to reduce the concentration of nitrogen in sewage treatment plant effluents.

Biomass - a quantitative estimate of the total mass of organisms for a particular population or community within a given area at a given time. Biomass for phytoplankton is measured as the total carbon within a liter of water. Biomass for the benthos is measured as the total ash-free dry weight per square meter of sediment habitat.

Chlorophyll *a* - a green pigment found in plant cells that functions as the receptor for energy in the form of sunlight. This energy is used in the production of cellular materials for growth and reproduction in plants. Chlorophyll *a* concentrations are measured in µg/L and are used as estimate of the total biomass of phytoplankton cells in the water column. In general, high levels of chlorophyll *a* concentrations are believed to be indicative of excessive growth of phytoplankton resulting from excess nutrients such as nitrogen and phosphorus in the water column.

Calanoid copepod - crustaceans of the subclass Copepoda and order Calanoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Acartia tonsa*) are one of the most important consumers of phytoplankton in estuarine systems.

Chlorophytes - algae belonging to the division Chlorophyta often referred to as true "green algae." Chlorophytes occur in unicellular, colonial and filamentous forms and are generally more common in tidal freshwater and oligohaline portions of estuaries.

Cladocerans - crustaceans of the class Branchipoda and class Cladocera commonly referred to as "water fleas." Although cladocerans are primarily found in tidal freshwater areas in estuaries, blooms of marine cladocerans periodically occur in higher salinity areas. Some smaller species such as *Bosmina longirostris* are believed to be indicators of poor water quality conditions.

Cryptomonads -algae belonging to the division Cryptophyta that have accessory pigments in addition to chlorophyll *a* which give these small flagellated cells a red, brown or yellow color.

Cyanobacteria - algae belonging to the division Cyanophycea that are procaryotic and that occur in single-celled, filamentous and colonial forms. In general, high concentrations of cyanobacteria are considered to be indicative of poor water quality.

Cyclopoid copepod - crustaceans of the subclass Copepoda and order Cyclopoida that are the dominant group of the mesozooplankton in marine systems. Copepods in this group (e.g. *Mesocyclops edax*) are one of the most important consumers of phytoplankton in estuarine systems.

Diatoms - algae belonging to the division Bacillariophyta that have a cell wall that is composed primarily of silica and that consists of two separate halves. Most diatoms are single-celled but some are colonial and filamentous forms. Diatoms are generally considered to be indicative of good water quality and are considered to be appropriate food for many zooplankton.

Dinoflagellates - biflagellated, predominately unicellular protists which are capable of performing photosynthesis. Many dinoflagellates are covered with cellulose plates or with a series of membranes. Some dinoflagellates periodically reproduce in large numbers causing blooms that are often referred to as "red tides." Certain species produce toxins and blooms of these forms have been implicated in fish kills. High concentrations of dinoflagellates are generally considered to be indicative of poor water quality.

Dissolved oxygen (DO) - the concentration of oxygen in solution in the water column, measured in mg/L. Most organisms rely on oxygen for cellular metabolism and as a result low levels of dissolved oxygen adversely affect important living resources such as fish and the benthos. In general, dissolved oxygen levels decrease with increasing pollution.

Dissolved inorganic nitrogen (DIN) - the concentration of inorganic nitrogen compounds including ammonia (NH_4), nitrates (NO_3) and nitrites (NO_2) in the water column measured in mg/L. These dissolved inorganic forms of nitrogen are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic nitrogen can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Dissolved inorganic phosphorus (PO4F) - the concentration of inorganic phosphorus compounds consisting primarily of orthophosphates (PO_4), The dissolved inorganic forms of phosphorus are directly available for uptake by phytoplankton by diffusion without first undergoing the process of decomposition. High concentrations of dissolved inorganic phosphorus can result in excessive growth of phytoplankton which in turn can adversely effect other living resources.

Estuary - A semi-enclosed body of water that has a free connection with the open sea and within which seawater is diluted measurably with freshwater derived from land drainage.

Eucaryote - organisms the cells of which have discrete organelles and a nucleus separated from the cytoplasm by a membrane.

Fall-line - location of the maximum upstream extent of tidal influence in an estuary typically characterized by a waterfall.

Fixed Point Stations - stations for long-term trend analysis whose location is unchanged over time.

Flow adjusted concentration (FAC) - concentration value which has been recalculated to remove the variation caused by freshwater flow into a stream. By removing variation caused by flow, the effects of other factors such as nutrient management strategies can be assessed.

Holoplankton - zooplankton such as copepods or cladocerans that spend their entire life cycle within the water column.

Habitat - a local environment that has a community distinct from other such habitat types. For the B-IBI of Chesapeake Bay seven habitat types were defined as combinations of salinity and sedimentary types - tidal freshwater, oligohaline, low mesohaline, high mesohaline sand, high mesohaline mud, polyhaline sand and polyhaline mud.

Hypoxic - condition in which the water column is characterized by dissolved oxygen concentrations less than 2 mg/L but greater than 0 mg/L. Hypoxic conditions typically result from excessive decomposition of organic material by bacteria, high respiration by phytoplankton, stratification of the water column due to salinity or temperature effects or a combination of these factors. Hypoxic conditions can result in fish kills or localized extinction of benthic communities.

Light attenuation (KD) - Absorption, scattering, or reflection of light by dissolved or suspended material in the water column expressed as the change in light extinction per meter of depth. Light attenuation reduces the amount of light available to submerged aquatic vegetation.

Loading - the total mass of contaminant or nutrient added to a stream or river generally expressed in lbs/yr.

Macrobenthos - a size category of benthic organisms that are retained on a mesh of 0.5 mm.

Meroplankton - temporary zooplankton consisting of the larval stages of organisms whose adult stages are not planktonic.

Mesohaline - refers to waters with salinity values ranging between 0.5 and 18.0 ppt.

Mesozooplankton - zooplankton with a maximum dimension ranging between 63 µm and 2000 µm. This size category consists primarily of adult stages of copepods, cladocerans, mysid shrimp, and chaetognaths, as well as, the larval stages of a variety of invertebrates and fish.

Metric - a parameter or measurement of community structure (e.g., abundance, biomass, species diversity).

Microzooplankton - zooplankton with a maximum dimension ranging between 2 µm and 63 µm. This size category consists primarily of single-celled protozoans, rotifers and the larval stages of copepods, cladocerans and other invertebrates.

Nauplii - earliest crustacean larval stage characterized by a single simple eye and three pairs of appendages.

Non-point source - a source of pollution that is distributed widely across the landscape surrounding a water body instead of being at a fixed location (e.g. run-off from residential and agricultural land).

Oligohaline - refers to waters with salinity values ranging between 0.5 and 5.0 ppt.

Oligotrich - protists of the phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems.

Percent of light at the leaf surface (PLL) - the percentage of light at the surface of the water column that reaches the surface of the leaves of submerged aquatic vegetation generally estimated for depths of 0.5 m and 1.0 m. Without sufficient light at the leaf surface, submerged aquatic plants cannot perform photosynthesis and hence cannot grow or reproduce.

Phytoplankton - that portion of the plankton capable of producing its own food by photosynthesis. Typical members of the phytoplankton include diatoms, dinoflagellates and chlorophytes.

Picoplankton - phytoplankton with a diameter between 0.2 and 2.0 µm in diameter. Picoplankton consists primarily of cyanobacteria and high concentrations of picoplankton are generally considered to be indicative of poor water quality conditions.

Pielou's evenness - an estimate of the distribution of proportional abundances of individual species within a community. Evenness (*J*) is calculated as follows: $J = H'/\ln S$ where H' is the Shannon - Weiner diversity index and S is the number of species.

Plankton - aquatic organisms that drift within and that are incapable of movement against water currents. Some plankton have limited locomotor ability that allows them to change their vertical position in the water column.

Point source - a source of pollution that is concentrated at a specific location such as the outfall of a sewage treatment plant or factory.

Polyhaline - refers to waters with salinity values ranging between 18.0 and 30 ppt.

Primary productivity - the rate of production of living material through the process of photosynthesis that for phytoplankton is typically expressed in grams of carbon per liter of water per hour. High rates of primary productivity are generally considered to be related to excessive concentrations of nutrients such as nitrogen and phosphorus in the water column.

Probability based sampling - all locations within a stratum have an equal chance of being sampled. Allows estimation of the percent of the stratum meeting or failing the benthic restoration goals.

Procaryote - organisms the cells of which do not have discrete organelles or a nucleus (e.g. Cyanobacteria).

Pycnocline - a rapid change in salinity in the water column indicating stratification of water with depth resulting from either changes in salinity or water temperature.

Random Station - a station selected randomly within a stratum. In every succeeding sampling event new random locations are selected.

Recruitment - The successful dispersal settlement and development of larval forms of plants or animal to a reproducing adult.

Reference condition - the structure of benthic communities at reference sites.

Reference sites - sites determined to be minimally impacted by anthropogenic stress. Conditions at theses sites are considered to represent goals for restoration of impacted benthic communities. Reference sites were selected by Weisberg et al. (1997) as those outside highly developed watersheds, distant from any point-source discharge, with no sediment contaminant effect, with no low dissolved oxygen effect and with a low level of organic matter in the sediment.

Restoration Goal - refers to obtaining an average B-IBI value of 3.0 for a benthic community indicating that values for metrics approximate the reference condition.

Riparian Buffer - An area of trees and shrubs a minimum of 100 feet wide located up gradient, adjacent, and parallel to the edge of a water feature which serves to: 1) reduce excess amounts of sediment, organic matter, nutrients, and other pollutants in surface runoff, 2) reduce soluble pollutants in shallow ground water flow, 3) create shade along water bodies to lower aquatic temperatures, 4) provide a source of detritus and large woody debris aquatic organisms, 5) provide riparian habitat and corridors for wildlife, and 6) reduce erosion of streambanks and shorelines

Rotifer - small multicellular planktonic animal of phylum Rotifera. These organisms are a major component of the microzooplankton and are major consumers of phytoplankton. High densities of rotifers are believed to be indicative of high densities of small phytoplankton such as cyanobacteria and as such are believed to be indicative of poor water quality.

Salinity - the concentration of dissolved salts in the water column measured in mg/L, ppt or psu. The composition and distribution of plant and animal communities is directly affected by salinity in estuarine systems. The effects of salinity on living resources must be taken into consideration when interpreting the potential effects of human activities on living resources.

Sarcodinians - single celled protists of the subphylum Sarcodina which includes amoeba and similar forms, characterized by possession of pseudopodia. Planktonic forms of sarcodinians typically have a external shell or test constructed of detrital or sedimentary particles and are important consumers of phytoplankton.

Secchi depth - the depth of light penetration expressed in meters as measured using a secchi disk. Light penetration depth directly affects the growth and recruitment of submerge aquatic vegetation.

Shannon Weiner diversity index - a measure of the number of species within a community and the relative abundances of each species. The Shannon Weiner index is calculated as follows:

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

where p_i is the proportion of the *i*th species and S is the number of species.

Stratum - a geographic region of unique ecological condition or managerial interest.

Submerged aquatic vegetation (SAV) - rooted vascular plants (e.g. eelgrass, widgeon grass, sago pondweed) that grow in shallow water areas . SAV are important in marine environments because they serve as major food source, provide refuge for juvenile crabs and fish, stabilize sediments preventing shoreline erosion and excessive suspended materials in the water column, and produce oxygen in the water column.

Threshold - a value of a metric that determines the B-IBI scoring. For all metrics except abundance and biomass, two thresholds are used - the lower 5^{th} percentile and the 50^{th} percentile (median) of the distribution of values at reference sites. Samples with metric values less than the lower 5^{th} percentile are scored as a 1. Samples with values between the 5^{th} and 50^{th} metrics are scored as 3 and values greater than the 50^{th} percentile are scored as 5. For abundance and biomass, values below the 5^{th} and above the 95^{th} percentile are scored as 1, values between the 5^{th} and 25^{th} and the 75^{th} and 95^{th} percentiles are scored as 3 and values between the 25^{th} and 75^{th} percentiles are scored as 5.

Tidal freshwater - refers to waters with salinity values ranging between 0 and 0.5 ppt which are located in the upper reaches of the estuary at or just below the maximum upstream extent of tidal influence.

Tintinnid - protists of phylum Ciliophora and order Oligotricha. These ciliates are important predators of small phytoplankton in marine systems. Tintinnids are distinguished from other members of this group because they create an exoskeleton or test made of foreign particles that have been cemented together.

Total nitrogen (TN) - the concentration of both inorganic and organic compounds in the water column which contain nitrogen measured in mg/L. Nitrogen is a required nutrient for protein synthesis. Inorganic forms of nitrogen are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total phosphorus (TP) - the concentration of both inorganic and organic compounds in the water column which contain phosphorus measured in mg/L. Phosphorus is a required nutrient for cellular metabolism and for the production of cell membranes. Inorganic forms of phosphorus are directly available for uptake by phytoplankton while organic compounds must first be decomposed by bacteria prior to being available for use for other organisms. High levels of total nitrogen are considered to be detrimental to living resources either as a source of nutrients for excessive phytoplankton growth or as a source of excessive bacterial decomposition that can increase the incidence and extent of anoxic or hypoxic events.

Total suspended solids (TSS) - the concentration of suspended particles in the water column, measured in mg/L. The composition of total suspended solids includes both inorganic (fixed) and organic (volatile) compounds. The fixed suspended solids component is comprised of sediment particles while the volatile suspended solids component is comprised of detrital particles and planktonic organisms. The concentration of total suspended solids directly affects water clarity which in turn affects the development and growth of submerged aquatic vegetation.

Zoea - last planktonic larval stage of crustaceans such as crabs and shrimp. Numbers of crab zoea may reflect the recruitment success of adult crabs.

Zooplankton - the animal component of the plankton which typically includes copepods, cladocerans, jellyfish and many other forms.