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CHESAPEAKE BAY PROGRAM

STUDY OF AN ESTUARY

TECHNICAL REPORT NO.

J104-121

SUBMITTED TO

U. S. ENVIRONMENTAL PROTECTION AGENCY
401 M Street, SW - WH 586
Washington, DC 20460

SUBMITTED BY

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Technical Report No.
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1.0 INTRODUCTION

On September 30, 1983, the Environmental Protection Agency, Chesapeake Bay Program (EPA, CBP) in Annapolis, Maryland ended a remarkable episode in the history of the Bay community. Within a seven-year period, the CBP united organizations that had once been divided on Bay issues toward successfully completing research and agreeing on management recommendations.

The Chesapeake Bay Program was formed at the direction of the 94th Congress, as delineated in Senate Report 94-326. The legislation required EPA to:

> Assess the principal factors having an adverse impact on the environmental quality of the Chesapeake Bay as perceived by scientists and users.
>
> Establish mechanisms for collecting, storing, analyzing, and disseminating environmental data.
>
> Analyze available environmental data and implement methods for improved data collection.
>
> Propose alternative control strategies for long-term protection of the Bay.
>
> Evaluate Bay management coordination mechanisms to best assure timely implementation of control strategies.

Senator Charles McC. Mathias, Jr. designed the legislation authorizing CBP to coordinate the efforts of diversified groups of scientists, managers, policy makers, and citizens into a single cooperative effort. EPA was directed to "conduct an in-depth study of the Chesapeake Bay, which shall also be applicable to other estuarine zones." The interdisciplinary research approach used in studying the nation's largest estuary may be beneficial to officials seeking an exemplary program for future studies.

1.1 PURPOSE OF THIS REPORT

The Office of Water Regulations and Standards within EPA requested Statistical Consultants, Inc. (SCI) to review the CBP in terms of approaches used in directing an environmental research study toward management recommendations. This report, "The Study of an Estuary," addresses the most commonly asked questions about the CBP:

> Why was such an intensive study of the Chesapeake Bay necessary?
>
> How was research involving more than thirty agencies, research institutions, citizens organizations, and forty research projects directed and integrated?
>
> In retrospect, what are the lessons learned from the processes used?

In the past, emphasis by EPA was placed on the study of freshwater systems. Only in recent years has that effort been extended to estuarine ecology. A variety of federally-funded reports on estuaries have been published including the National Estuary Study (Department of the Interior, 1970), the Status of Estuaries (U.S. EPA, 1975), and Coastal Ecological Systems of the United States (Federal Water Pollution Control Administration, prepared in 1968-69 and published in 1974). Significant efforts were made on a world-wide basis, such as the Jekyll Island Conference in 1964 and the environmental conference sponsored by the NATO Committee on the Challenges of Modern Society. While publications and meetings abound on various aspects of estuarine science, there is still a lack of clear, thorough descriptions of important processes and resources, both from managerial and scientific standpoints.

The Chesapeake Bay received intensive study from 1976 to 1982, substantially increasing our understanding of that estuary, but the study has by no means answered all the questions. By successfully integrating scientific research and data collection regarding the water quality of the Bay, managers now have sound information upon which to base decisions. This report's documentation of the processes used may aid EPA and state agencies in attempts to study other estuaries.

1.2 ORGANIZATION OF THIS REPORT

This report is arranged in chronological order of events leading to the formation of the CBP and of events occurring during the Program. Accounts leading to the inception of the CBP are contained in Chapter 2, "Evolution of the Chesapeake Bay Program," followed by the Program's three major phases. Chapter 3, "Phase I: Initiation and Planning (1976-1979)," describes the organizational structure, funding, selection of research, and reorganization. Chapter 4, "Implementation of Research (1977 to 1982)," highlights key meetings and workshops involving synthesis of research, characterization of water quality trends and resources, and management tools used to drive research toward management recommendations. Chapter 5, "Phase III: Establishing a Framework for Management Recommendations," emphasizes approaches used in coordinating various Bay organizations into the decision-making process. Each chapter concludes with a section on "lessons learned." The lessons learned are not necessarily the opinions of any one group involved with the CBP. Instead, numerous state and federal officials were consulted; interviews took place with former CBP employees; letters were sent to key scientists for recommendations; and reports prepared by the Chesapeake Bay Foundation, Inc. and the Congressional Research Service were considered. This analysis is a critique of the management and policy aspects of the Program, rather than technical aspects of the CBP.

1.3 MAJOR CHESAPEAKE BAY PROGRAM FACTS AND FINDINGS

Three major areas (toxicants, nutrients, and submerged aquatic vegetation (SAV)) were intensively studied by the Chesapeake Bay Program. These studies enabled the CBP to relate findings to impacts on natural resources. The CBP resulted in four major reports regarding the scientific facts, findings, and management recommendations:

CHESAPEAKE BAY: INTRODUCTION TO AN ECOSYSTEM

Served as a reference for other reports by explaining the important ecological relationships within the Bay.

CHESAPEAKE BAY PROGRAM TECHNICAL STUDIES: A SYNTHESIS

Summarized and explained the technical knowledge gained from the research projects funded by the CBP in the areas of toxic substances, nutrients, and SAV.

CHESAPEAKE BAY: A PROFILE OF ENVIRONMENTAL CHANGE

Assessed trends (i.e., characterized) in water and sediment quality and living resources over time and examined the relationship between the two.

CHESAPEAKE BAY: A FRAMEWORK FOR ACTION

Identified control alternatives for agriculture, sewage treatment plants, industry, urban runoff, and construction. It gives an estimate of costs and effectiveness of different approaches to remedy problem areas.

The CBP built a scientific data base which is probably the largest in volume for a single estuary. It received excellent quality control making it a sound data base. The state agencies in Maryland, Virginia, and Pennsylvania, as well as Bay research universities, contributed to and rely on the CBP data base in formulating state water quality plans and conducting research programs. Many federal agencies also contributed critical data to the CBP data base.

An unpublished report prepared by the Chesapeake Bay Program in September 1983 summarizes the major facts and findings of the CBP as described in Sections 1.3.1 to 1.3.6.

1.3.1 Trends in Living Resources

In the upper Bay an increasing number of blue-green algal or dinoflagellate blooms has been observed in recent years. In fact, cell counts have increased approximately 250-fold since the 1950's. In contrast, the algal populations in the upper Potomac River have recently become more diverse, with the massive blue-green algal blooms generally disappearing since nutrient controls were imposed in the 1960's and early 1970's in this segment of the Bay watershed.

Since the late 1960's, submerged aquatic vegetation has declined in abundance and diversity throughout the Bay. The decline is most dramatic in the upper Bay and western shore tributaries. An analysis over time indicates that the loss has moved progressively down-stream, and that present populations are mostly limited to the lower estuary.

Landings of freshwater-spawning fish such as shad and alewife have decreased. Striped bass landings, after increasing through the 1930's and 1940's, have also decreased, especially since 1973. Harvests of marine-spawning fish, such as menhaden and bluefish, have generally remained stable or increased. The increased yield of marine spawners and decreased yield of freshwater spawners represent a major shift in the Bay's fishery. Over the 100-year period from 1880 to 1980, marine spawners accounted for 75 percent of the fishery; during the interval from 1971 to 1980, they accounted for 96 percent.

Oyster harvests have also decreased Bay-wide. Oyster spat set has declined significantly in the past 10 years as compared to previous years, particularly in the upper Bay and western shore tributaries and some Eastern Shore tributaries, such as the Chester River. The decline in oyster harvest has been somewhat offset by recent increases in the harvest of blue crabs which may be due to increased fishing effort. As a result, the Bay-wide landings of shellfish have not changed greatly over the last twenty years. However, overall shellfish harvest for the western shore has decreased significantly during this period.

Increasing levels of nutrients are entering many parts of the Bay: the upper reaches of almost all the tributaries are highly enriched with nutrients; lower portions of the tributaries and eastern embayments have moderate concentrations of nutrients; and the lower Bay does not appear to be enriched. (See Figure 1 for a map of the Bay). Data covering 1950 to 1980 indicate that in most areas water quality is degrading, partially because increasing levels of nutrients are entering the waters. Only in the Patapsco, Potomac, and James Rivers (and some smaller areas) is there improvement in water quality; this is evidently largely due to pollution control efforts in those areas.

The amount of water in the main part of the Bay, which has low or no dissolved oxygen, has increased about fifteen-fold between 1950 and 1980. Currently, from May through September in an area reaching from the Annapolis Bay Bridge to the Rappahannock River, much of the water deeper than 40 feet has no oxygen and, therefore, is devoid of life. The dissolved oxygen levels in the Bay have been affected by nutrient enrichment. The excessive

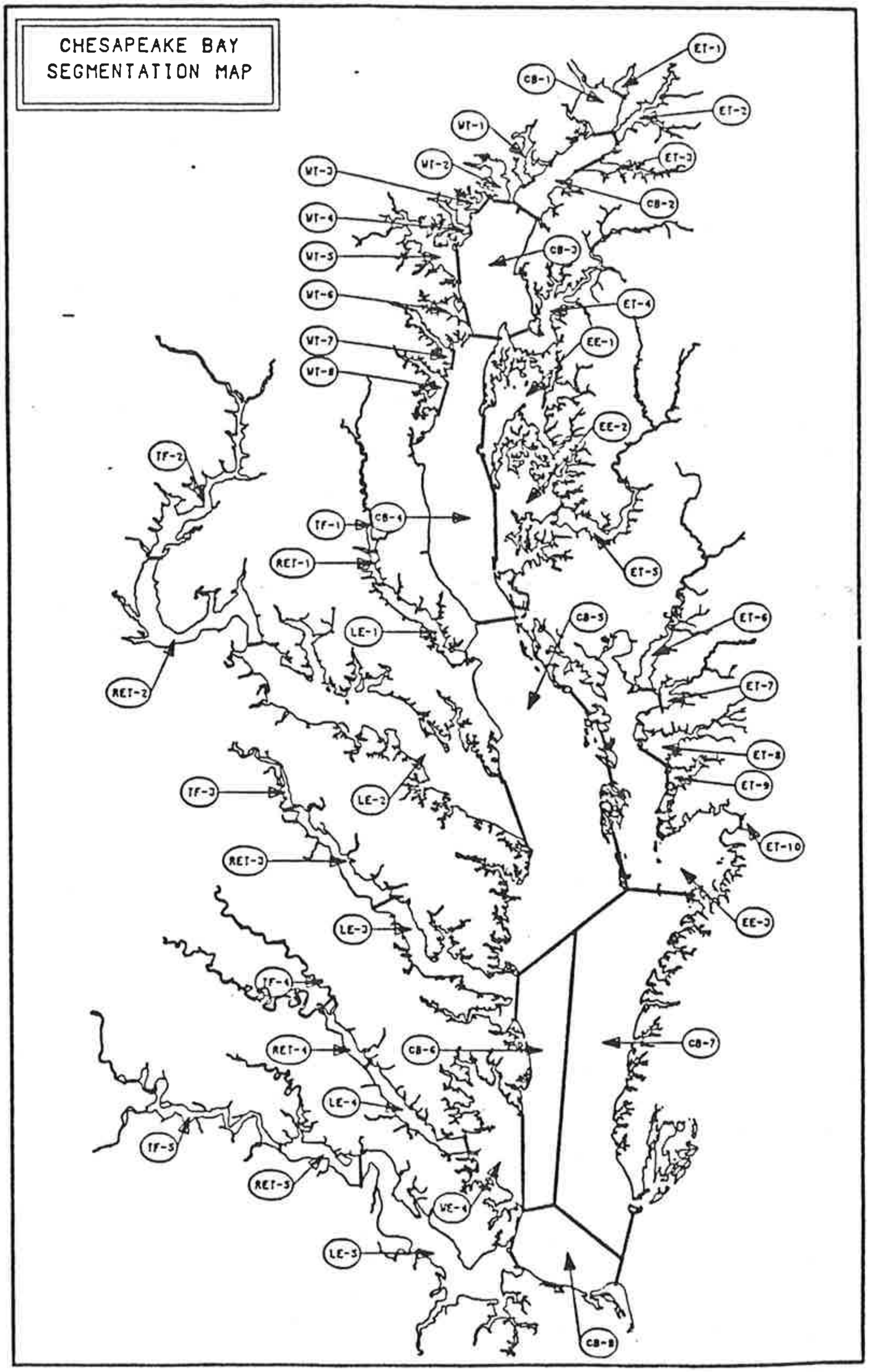

Figure 1. Chesapeake Bay Program segments used in data analysis

loads of nutrients which enter the Bay stimulate the growth of undesirable large algal blooms. As the algae die and settle to the bottom, they decay and consume the oxygen that is crucial for Bay organisms, such as crabs, oysters, and fin fish. Although these processes occur naturally in an estuarine system, they appear to have become far more severe in the Bay in recent years as nutrient inputs have increased.

High concentrations of toxic organic compounds are in the bottom sediments of the main Bay near known sources, such as industrial facilities, river mouths, and areas of maximum turbidity. Highest concentrations were found in the Patapsco and Elizabeth Rivers where several sediment samples contained concentrations exceeding 100 parts per million. These general patterns suggest that many of these toxic substances adsorb to suspended sediment and then accumulate in areas dominated by fine-grained sediments. Benthic organisms located in such areas tend to accumulate the organic compounds in their tissues.

Many areas of the Bay have metal concentrations in the water column and sediment that are significantly higher than natural (background) levels. In fact, many violations of water quality criterion were noted. Also, Bay sediments in the upper Potomac, upper James, small sections of the Rappahannock and York Rivers, and the upper mid-Bay had high levels of metal contamination. The most contaminated sediments--with concentrations greater than 100 times natural background levels--are in the industrialized Patapsco and Elizabeth Rivers.

1.3.2 Relationships between Living Resources and Water Quality

In summary, valued resources of the Bay are declining. This trend parallels an increase in nutrients and toxicants throughout the Bay. A geographic characterization and analysis of segments of the Bay suggest a relationship between the resources and the water and sediment quality. In areas of the Bay afflicted by high concentrations of nutrients and toxicants, such as Baltimore Harbor and the Elizabeth River, there is no submerged aquatic vegetation. In fact, only a few hardy organisms can survive in this hostile environment. On the other hand, in certain areas of the Eastern Shore where the nutrient and toxicant concentrations are still fairly low, submerged aquatic vegetation still grows, and crabs, oysters, and fin fish are plentiful.

Although the circumstantial evidence appears to be compelling, the CBP cannot definitively link the trends seen in the resources to the Bay's deteriorating water quality. There are other factors affecting the abundance of the grasses and fish, including over-fishing, climatic trends, and physical alterations of the Bay associated with dredging and filling. It is quite probable that there is no "single bullet," but rather a myriad of ecological stresses. However, it is clearly established that nutrient loadings have substantially increased, that massive quantities of toxicants have entered this system, and that the unchecked increases of these pollutants threaten important resources.

The increase in nutrients and the corresponding decrease in dissolved oxygen are affecting the living resources of the Bay. Conceptually, one would expect to see a positive relationship between nutrients and Bay productivity. As these nutrients (which are essentially fertilizer) increase, one would expect to see an increase in plant production and, as a result, fish harvest. However, if too many nutrients are added, the excessive growth of undesirable weed-like plants, such as blue-green algae, is encouraged. This prevents the growth of desirable plants such as submerged aquatic vegetation. Chesapeake Bay Program findings suggest that this situation is occurring in the Bay. Areas of the Bay that have relatively low nutrient concentrations, such as the eastern embayments, have abundant submerged aquatic vegetation; however, areas of the Bay that have high nutrient concentrations, such as the upper Bay, have very little vegetation.

There is also a similar, but not as precise, relationship between nutrients and Bay fisheries. Fish that spawn in the freshwater, nutrient-enriched upper sections of the tributaries are decreasing. Also, oysters and other commercial shellfish that live all their life on the Bay bottom are reduced in abundance, possibly in part due to the elimination of their habitat by low dissolved oxygen. Although the decline in desirable resources cannot be definitively linked to the increase in nutrients, there is sufficient evidence to recommend corrective actions in controlling nutrient discharges to the Bay.

1.3.3 Sources of Nutrients

The Bay Program examined in detail the sources of nutrients entering the Bay and the relative contributions of different types of sources. In addition, an assessment was made of changing land-use activities, such as the intensification of agricultural activities and urbanization, which have strong implications for the levels of pollutants going into the Bay. For example, as the population continues to increase in and around the metropolitan areas of the Bay, the volume of municipal effluent will also increase proportionately. If current projections prove true and if present treatment practices continue, the volume of municipal effluent generated and discharged is expected to increase 36 percent by the year 2000.

Special attention was also given to assessing the relative importance of point versus nonpoint sources in various sections of the Bay watershed as a basis for targeting management and control strategies. For example, the nutrient input from the Susquehanna River basin is principally from nonpoint sources, particularly from agricultural lands; in contrast, the input into the West Chesapeake Bay basin (which is composed of several rivers, including the Patapsco, Back, and Gunpowder basins) is dominated by point sources, particularly municipal sewage treatment plants. A strategy for nutrient reduction in each of these basins would logically focus on controlling the dominant sources. Below is a more detailed summary of the variations in the sources of nutrients entering the Bay.

Point sources are concentrated waste streams discharged to a water-body through a discrete pipe or ditch. Although there may be daily or seasonal fluctuations in flow, they are essentially continuous daily discharges which occur throughout the year. The significance of point sources increases during the summer and other periods of low rainfall because the dilution of effluent by receiving water is reduced. Conversely, their relative significance decreases during periods of wet weather when rainfall, runoff, and nonpoint loadings increase. Examples of point sources include discharges from industrial production facilities and discharges from publicly owned treatment works (POTW's). The CBP data base contains an inventory of over 5,000 industrial and municipal point sources located within the Chesapeake Bay drainage area.

Nonpoint sources of nutrients include runoff from forests, farmland, residential and commercially developed lands, groundwater flow, and atmospheric deposition on land and water. Within the major river basins discharging to Chesapeake Bay, changes in population, land use, and land management are occurring which alter stormwater runoff quality and the rate of discharge. These changes affect the size and nature of nonpoint source loadings to the Bay. The diffuse nature of nonpoint sources render them difficult both to quantify and control. In addition, nonpoint source loads are largely determined by unpredictable rainfall patterns. In wet years nonpoint source loads are generally very high and in dry years are low. The nonpoint source runoff from cropland contributes the largest share of the nonpoint source nutrient load to the Bay. Although a minor contributor to the Bay-wide nutrient load, urban runoff causes localized water quality problems.

1.3.4 Nutrient Loadings

The Chesapeake Bay Program estimated present (1980) and future (2000) nutrient loadings delivered to the Bay from throughout its drainage basin. The fractions of nutrient loadings originating from point sources and nonpoint sources (agricultural and urban runoff) were also determined. In general, the nitrogen entering Bay waters is contributed primarily by nonpoint sources which are dominated by cropland runoff loadings. Point sources, on the other hand, and especially sewage treatment plants are the major source of phosphorus to Chesapeake Bay. It is important to note again that point source nutrient discharges tend to be more dominant in dry years than in wet years. In contrast, nonpoint sources which enter waterways primarily in stormwater runoff contribute a greater share of total nutrient loadings during wet years.

Basin-wide point sources contribute about 33 percent of the total nitrogen load to the Bay. However, point sources contribute a larger share of the phosphorus load, averaging 61 percent. Nonpoint sources contribute the difference in the nitrogen and phosphorus loads, making up 67 and 39 percent of the total loads, respectively. Most of the nitrogen entering Chesapeake Bay waters has been transported from watersheds throughout the Bay basin; phosphorus loadings originate mostly from sources adjacent to the Bay (below the fall line).

The three largest tributaries of the Bay, the Susquehanna, Potomac, and James Rivers, carry most of the nitrogen (78 percent) and phosphorus (70 percent) loads that enter the tidal waters of Chesapeake Bay. Although the West Chesapeake basin centered near Baltimore is not a large land area compared to other basins, it contributes significant amounts of nutrients to the Bay. The Eastern Shore and the Patuxent, Rappahannock, and York River basins contribute the smallest portion of the Bay-wide nutrient loads.

To link loadings of nutrients with specific areas where nutrient and dissolved oxygen concentrations potentially limit aquatic resources, it is necessary to understand the relative contributions of point and nonpoint sources by major river basin. It is also necessary to determine inputs in dry, average, and wet years. Only then can decisions be made on the best course of action to reduce nutrients contributing to a certain problem.

Analysis by a computerized model demonstrates that point source loads of phosphorus exceed the nonpoint source loads from the Potomac and James River basins in almost all rainfall conditions. In contrast, the nonpoint sources contribute most of the phosphorus from the Susquehanna River basin under all conditions. This finding reflects the fact that the James and Potomac River basins contain major population centers which contribute large point source loadings to tidal waters, unlike the more rural Susquehanna basin. It is not surprising that, in the urbanized Patuxent and West Chesapeake basins, the phosphorus loadings from point sources exceed those from nonpoint sources; and in the largely rural Eastern Shore and Rappahannock and York River basins, nonpoint contributions are always the dominant source of phosphorus.

Nitrogen loadings from the major river basins are more often dominated by nonpoint sources than are phosphorus loadings. In the Susquehanna, nonpoint sources provide most of the nitrogen under all conditions. In the Potomac River basin the nonpoint sources of nitrogen dominate under all hydrologic conditions. Most of the nitrogen load in the James River comes from point sources; however, nonpoint sources become important in a wet year. Point source loads of nitrogen always exceed nonpoint sources in the West Chesapeake; however, in the Patuxent River basin, point sources of nitrogen are only dominant under dry conditions. Loadings of nitrogen from the Eastern Shore and the Rappahannock and York River basins originate primarily from nonpoint sources, as do those of phosphorus.

1.3.5 Toxic Compounds

Toxic compounds are affecting the Bay's resources especially in urbanized areas. These compounds include metals, such as cadmium, copper, and lead; organic chemicals, such as PCB's, Kepone, and DDT; and other chemicals, such as chlorine. Low concentrations of these toxic compounds have little effect on organisms. However, increasingly higher concentrations of toxic compounds can cause reduced hatching and survival, gross effects, such as lesions or fin erosion in fish, and eventually the mortality of an entire population. Toxicants can affect the ecosystem by eliminating sensitive species and producing communities dominated by a few pollution-tolerant forms. In localized areas of the Bay, the CBP has found evidence of such toxic stress.

Chesapeake Bay Program research has shown a relationship between the levels of toxic compounds found in the sediments in certain areas and the survival of individual organisms and the resulting health of the ecosystem. Bioassay studies of a small amphipod that lives in the bottom sediments of the Bay indicate that its chance of survival significantly decreases when it is exposed to polluted Bay sediments. When the amphipods were exposed to "uncontaminated" Bay sediment that had natural levels of metals and organic substances, they all survived. However, when the amphipods were exposed to highly contaminated sediments from the inner harbors of the Patapsco and Elizabeth Rivers, they all died. Moderately contaminated sediments produced intermediate levels of mortality.

The fact that this particular organism could not live in these highly contaminated sediments suggests that other organisms cannot live in such conditions. Studies of these areas confirm this theory. Those areas of the Patapsco River that have highly toxic sediments support only a few types of organisms--primarily worms (low diversity); areas that are not as contaminated have many different organisms, including crabs, clams, oysters, and amphipods. These findings reinforce the need for careful control of toxic compounds.

Toxic materials enter the Bay from a variety of sources, including industrial effluents and other point sources, runoff from urban areas and agricultural lands, atmospheric inputs, and disposal of contaminated dredge spoil. Except for long-range atmospheric deposition, the primary sources are located within the basin.

Industrial facilities and sewage treatment plants discharge a variety of metals and synthetic organic compounds. Chlorine and chlorinated organics are also common constituents of effluent from industries, POTW's, and power plants. The CBP analyzed the effluent from 20 industries and eight POTW's; over 75 percent of the facilities had toxic substances in the effluent. Point sources of toxics appear to be most significant in industralized areas, such as Baltimore and Norfolk.

The three major tributaries to Chesapeake Bay, the Susquehanna, Potomac, and James Rivers, deliver metals and organic compounds from urban and agricultural lands. In addition, deposits of air pollution are delivered directly to Bay waters and also indirectly through urban runoff. One example is automobiles which contribute large amounts of lead from gasoline. Another important nonpoint source is shore erosion which contributes significant amounts of iron and other metals to the Bay. Also, maritime ships and leisure and work boats occasionally leak or spill petroleum and are regularly treated with copper-based anti-fouling paints. The toxicants associated with maritime activities reach their highest levels in harbors and marinas where these activities are most concentrated and natural flushing is low.

1.3.6 Loadings of Toxic Compounds

The Chesapeake Bay Program estimated metal loadings delivered to the Bay from the entire drainage basin. Although the CBP was unable to quantify the loadings of organic compounds to the Bay, it is probable that the relative contribution of different sources would be similar to that estimated for metals. In general, the Susquehanna, Potomac, and James Rivers are major sources of toxicants entering the tidal Bay. Effluent from industries and sewage treatment plants located directly on the Bay are also important. In urbanized areas, such as Baltimore, Washington, DC, and Hampton Roads, urban runoff can contribute significant loadings of toxicants.

The CBP detected over 300 organic compounds in the water and sediments of the Bay; up to 480 organic compounds were detected in Baltimore Harbor. Most of the compounds identified were toxic. The mean concentrations of all organic compounds detected were typically in hundreds of parts per million. Priority pollutants were detected in all areas sampled and about half were found in concentrations greater than 50 parts per billion. In general, the compounds observed showed a trend of high concentrations adjacent to urbanized areas, such as Baltimore and Hampton Roads. High concentrations are also found in the Susquehanna Flats. In the southern Bay, high concentrations exist near river mouths.

Although the CBP is unable to quantify the loadings of organic compounds, the fact that high concentrations of many of these compounds were detected in analyses of effluents from industries and sewage treatment plants suggests that the major source of toxic loadings is point sources. Furthermore, in several instances the CBP was able to link the compounds with specific industrial sources. It is essential that the release of such compounds be substantially reduced and that Bay sediments and point source effluents be thoroughly monitored.

The James, Potomac, and Susquehanna River systems are by far the major transport mechanisms for each metal examined by the CBP. Collectively, they account for 69 percent of the cadmium, 72 percent of the chromium, 69 percent of the copper, 80 percent of the iron, 51 percent of the lead, and 54 percent of the zinc discharged to the Bay system. The other principal source of each metal is: for cadmium--industry (13 percent); for chromium and iron--shore erosion (13 percent and 18 percent, respectively); for copper--industrial and municipal point sources (21 percent); for lead--urban runoff (19 percent); and for zinc--atmospheric deposition (31 percent).

The Chesapeake Bay Program's research has documented the serious impact of the nutrients and toxic chemicals released from point and nonpoint sources on the Bay's water and sediment quality and on the vitality and abundance of its living resources. Moreover, forecasts indicate that the sources of these pollutants will continue to grow in number and change in nature, resulting in corresponding increases in the levels of the pollutants entering the Bay. The present state of the Bay and the forecast for the future provide the basis for the recommendations set forth in the following chapter. It is essential that we act now to control and alter human activities and practices on land if we are to halt the deterioration of the Bay and the subsequent losses of animal and plant life they produce.

1.4 CHRONOLOGY OF THE CHESAPEAKE BAY PROGRAM

The Chesapeake Bay Program spanned seven years of continuous planning, research, workshops, and meetings geared toward management solutions. The following chronology is included as an overview to subsequent sections of this report.

1960-1970	Public expresses environmental concern.
October 1975	P.L. 94-116 authorizes the CBP.
May 1976	EPA Administrator Train announces "The Chesapeake Bay Water Quality Program."
January 1977	Policy Advisory Committee agrees to "Phased Management Approach" and announces organizational structure.
October, 1977	Research study areas are selected: SAV, toxic substances, nutrient enrichment.
1978	Ten million dollars in research money released. Citizens Program for the Chesapeake Bay receives EPA grant.
November 1978	Research is initiated.
January 1979	Hearing before the subcommittee on Governmental Efficiency and the District of Columbia, Committee on Governmental Affairs, United States Senate. Reorganization of CBP. Office is moved to Annapolis under the directorship of ORD/EPA.
November 1979	Annual meeting in Hampton Roads--First gathering of technical community. Research progress is reported and a need to integrate research is established.
January 1980	Decision made to do mathematical models of Chesapeake Bay to link with management options.
October 1980	Ocean City Peer Review Meeting--A need to characterize Bay water quality is recognized.
December 1980	Cross Keys Meeting--Shift from research to management solutions.
1978 - 1980	Individual Reports--40 projects are completed, peer reviewed, and published.
March 1981	Donaldson Brown Workshop--Held to synthesize research findings and respond to management questions.
1980 - 1982	Synthesis Report compiled and published.
1981 - 1983	Characterization Report compiled and published.
1982 - 1983	Management Report compiled and published.
1983 - Future	Implementation of Management strategies.

2.0 EVOLUTION OF THE CHESAPEAKE BAY PROGRAM

The question often arises as to why a study of the Chesapeake Bay was necessary. The answer rests largely in the public sensitivity regarding the fate of the Bay as the views of the public were expressed through newspapers and public forums. The Chesapeake Bay Program can be described as a combined government and citizen program to document the health of the Bay through careful research and to provide the scientific information needed to inform Bay citizens about the complex Bay ecosystem and the options available for improving its environmental quality.

2.1 ENVIRONMENTAL CONSCIOUSNESS

The environmental consciousness which existed in the United States during the 1960's and 1970's focused attention on the health of the Chesapeake Bay. As might be expected, special interest groups blamed each other for such conditions as declines in some commercial fish species, the emergence of red tides and other eutrophic indicators, and the loss of submerged aquatic vegetation (SAV), a migratory waterfowl food source and a nursery haven for fish.

Causes for deteriorating conditions in the Bay were speculative. Technology was viewed as one threatening factor. For example, citizens in Maryland questioned the effects on biota of increased water temperatures caused by power plant cooling systems. Scientists could not reach agreement among themselves regarding such effects. Toxic chemicals added additional fears regarding the health of the Bay. The chlorinated hydrocarbon, Kepone, discharged into the James River in 1973, stirred Bay-wide alarm regarding the transport of the pollutant throughout the food chain. The effects of these factors on the health of the Bay were uncertain.

Population growth was still another concern to the Chesapeake Bay community. The population of the Chesapeake Bay region, as projected by the Corps of Engineers "Chesapeake Bay Future Conditions Report," was expected to increase from 8,000,000 in 1980 to over 16,000,000 by 2020. Typical was this statement by the Virginia Fisheries Commission in 1971: "Contamination of our natural waters by primary and secondary pollution is one of the most major problems confronting the seafood industry . . . Our paramount concern at the present is the problems of municipal sewage."

The press played a critical role in raising public awareness regarding the health of the Bay. Local news articles during the 1960's and 1970's recorded the uncertainty about the condition of the Bay. Boldprint headlines such as these told the story: "Are They Killing Our Bay?", "Changes Imperil Bay Resources," and "Our Beleagured Bay." Government responded to pressure from the press by implementing short-term programs to address isolated incidents. The need for a coordinating group responsible for the long-term water quality of the entire Bay became increasingly apparent.

Senator Mathias realized the need for an in-depth study of the Bay and for effective Bay management. In the summer of 1973, Senator Mathias took a Bay-wide cruise to confirm first-hand the public's perception that the Bay was dying. He authored the legislation governing the Chesapeake Bay Program and spoke fervently about Bay management:

> The Bay is an organic whole. If one part is damaged, all parts are affected. It is of little use to study one link in an environmental chain without relating it to the whole. If the Chesapeake Bay is to survive, it must be addressed as an entity, as a total system, without duplication and without omission. We sorely need a mechanism that can coordinate the activities and organizations involved in the Bay--that can offer some promise that the hopes and aspirations we all have for the Bay can be realized.

The need for a comprehensive look at the Bay did not develop overnight. As seen from the above accounts, concern for the Bay evolved over time, culminating with Senator Mathias' personal involvement.

2.2 THE CLEAN WATER ACT

The Federal Water Pollution Control Act (PL-500), also known as the Clean Water Act, sets the overall framework for the Nation's goal of attaining and maintaining "fishable/swimmable" waters. Within this overriding goal, the Act sets forth EPA and state responsibilities for developing control actions and strategies to abate pollutant sources. The Chesapeake Bay has received a special emphasis by EPA due to its size and productivity, and its overall importance to the Nation, and more specifically, the Bay states.

Although it was seen fit to provide a special research appropriation to study the Bay, it should be recognized that other research studies could and have been carried out within the context of the Act. Many research studies conducted by EPA outside of this special appropriation are directly or indirectly of use to the Bay system as well. Similarly, the control actions that are necessary to resolve the Bay's problems can be addressed through the Act. These control actions fall into the two distinct phases anticipated by the Act: (1) technology based, and (2) water quality based.

Technology based controls are issed by EPA on a national basis. All dischargers within a certain category, e.g., iron and steel industry and publicly owned treatment works, are required to meet common effluent standards. Should these effluent standards fail to achieve the ambient water quality standards of a given waterbody, the state is to impose additional control actions to ensure that ambient standards are attained. These additional controls are known as water quality based controls. These ambient standards are adopted by the state and comprise a use, e.g., shellfishing, and criteria protective of that use. All state standards are subject to EPA review to ensure, among other things, that downstate uses are not impaired.

Additional water quality based control actions can include point and nonpoint source controls. The procedures for adopting water quality based controls are described in the Act and in EPA regulations and policy. Indeed, much of the information necessary to make water quality based control actions should be available through basin and areawide plans conducted under sections 208 and 303 of the Act.

2.3 PUBLIC LAW 94-116

Little coordination existed among legislators, managers, scientists, and the public regarding management of the Chesapeake Bay until Congressional action on October 17, 1975 (P. L. 94-116). This legislation was a result of environmental concerns described in Section 2.1 of this report. Scientists were hampered by lack of funding and by vague knowledge of related Bay research. Conferences on Bay issues helped clarify areas of research but did not result in leadership for the management of the Bay. This statement by Senator Mathias in 1979 describes ongoing confusion regarding Bay management:

> It takes three pages of very small print just to list the names and addresses of organizations concerned with the Bay; it takes 14 pages to describe what they do; there are ten federal agencies with some jurisdiction over the Bay; there are five interstate agencies and commissions; Maryland and Virginia together have 31 state agencies dealing with the Bay; and there are seven Maryland and Virginia colleges and universities studying the Bay.

One step toward coordination and management of the Bay was passage of P. L. 94-116 which directed the Environmental Protection Agency to reprogram $25 million to conduct a five-year study of the environmental quality and management of Chesapeake Bay resources. The directives of Congress were outlined in the accompanying Senate Report No. 94-326. CBP's response to the specific mandates of Congress was assessed by The Chesapeake Bay Foundation (CBF), a non-profit organization, at a Congressional Hearing in March 1983.

The following excerpts taken from the CBF's preliminary assessment indicate that the mandates were met.

A. MANDATE: CONDUCT AN IN-DEPTH STUDY OF THE CHESAPEAKE BAY, APPLICABLE TO OTHER ESTUARIES.

EPA, through the Chesapeake Bay Program, has conducted an in-depth study of the Chesapeake Bay. As directed by Congress the study is applicable to other estuarine zones. This study had two primary components. First, the Program has amassed a very large data base on the physical, chemical, and biological characteristics of the Bay. These files comprise the first comprehensive historical data base for the Chesapeake. Second, the Program funded more than 40 technical studies dealing with a variety of topics germane to the estuary. In turn, these studies resulted in the compilation of 59 technical reports, adding greatly to our understanding of estuarine processes.

The Chesapeake Bay Foundation believes that the results of this study are applicable to the nation's other estuaries. Although the relative magnitude of the various processes will vary between individual estuaries, the same basic processes will nevertheless be present and important. Three CBP scientific findings have important implications:

1. The accumulation by "natural" processes of nutrients and toxicants in the Chesapeake Bay.
2. The identification of nitrogen as the potential limiting nutrient.
3. The coupling of land-use practices to nonpoint sources (NPS) pollution and the quantification of NPS pollution as a significant factor in the over-enrichment of an estuary.

B. MANDATE: ASSESS THE PRINCIPAL FACTORS ADVERSELY AFFECTING THE BAY.

The task of assessing the principal environmental factors affecting the Chesapeake Bay as set forth in the mandate to the Agency has been a difficult one. Initially, ten potential factors were identified as worthy of investigation by the Program based on responses from the Bay users and the region's scientific community. Given the limited fiscal resources made available to the Program, this list was narrowed to three factors as a result of a consensus reached by the Program and area scientists. We believe that the approach taken by the Program, targeting these three specific factors (nutrients, toxics, and submerged aquatic vegetation) of the many possible, was justified on the basis of available technical and fiscal resources. This approach, while not supplying all the answers to all the questions, did add considerably to our understanding of the estuary.

This is not to imply that other factors do not play an important role in modifying the estuary. Nor should we take the findings of the Program as the final word in the areas investigated. This is especially true with toxic contaminants. CBP research has shown that a number of areas have dangerously elevated levels of toxicants present. However, present scientific understanding does not permit us to draw correlations between the levels of toxicants present and the effects upon the biological resources of the Bay. For instance, too little is known on subjects such as the long-term effects of chronic exposure to particular compounds in estuaries or the synergistic effects that a combination of substances may exhibit. For this reason expanded monitoring and continued research is necessary.

C. MANDATE: REVIEW OF EXISTING RESEARCH AND ANALYSIS OF EXISTING DATA.

EPA's review of existing research programs appears to have been adequate. The relative success of this effort was due in large measure to the Program's extensive use of the region's major research institutions as cooperative partners in the technical studies. To our knowledge, no significant research programs were overlooked. In addition to the Program's review of the then ongoing research, historical data were compiled, edited, and stored by the Program. Literature, published and unpublished, and monitoring data from state and local governments, as well as private industry, are presently in the Program's computer files. In some areas, this information is difficult to interpret (e.g., historical fisheries data); in others it is presently incomplete (i.e., data from USGS Potomac Estuary Study, etc.). This does not, however, detract from the value of the data base as a whole. As it is upgraded and refined, it will be an extremely valuable tool in any attempt to monitor long-term trends in the estuary and its biological resources.

D. MANDATE: IDENTIFY THE UNITS OF GOVERNMENT RESPONSIBLE FOR MANAGING THE CHESAPEAKE BAY.

As set forth in the mandate, the Agency has identified the units of government that have management responsibilities for the Chesapeake Bay. This information, contained in a report entitled "Environmental Quality Management Study: Agency and Legal Authorities Survey," appears to be comprehensive. Prepared for the Program by the Environmental Law Institute (ELI), the document examines the federal, state, interstate, and regional management agencies, representative bodies of local government, research institutions, and legislative bodies with interests on the Bay. Although the document is dated (completed in December of 1980), it will serve as a resource for Bay managers and interested citizens, if made available.

Senate Report No. 94-326 also directed EPA to develop a program for coordination of research efforts, sampling, and data collection. EPA was further directed to define the management and institutional structure for improving communication and coordination necessary for Bay management. The CBF testified that the following questions remain unanswered relative to these directives:

1. Has the Agency (EPA) established a continuing capability for collecting, storing, analyzing and disseminating data related to the Bay and its management?

2. Has the Agency adequately reviewed ways to improve existing management mechanisms?

3. Will the Agency direct and coordinate an abatement program that will address the factors affecting the Chesapeake Bay?

Since the CBF testimony in March 1983, the Chesapeake Bay Program has completed a report entitled "Chesapeake Bay: A Framework for Action." This report identifies control alternatives for agriculture, sewage treatment plants, industry, urban runoff, and construction. It gives an estimate of costs and effectiveness of different approaches to remedy problem areas. This report is described in more detail in Section 5.

2.4 ESTABLISHMENT OF THE CHESAPEAKE BAY PROGRAM

Organizing the many groups concerned with the Bay was a huge task. EPA sought to do this through a combined research and abatement program. On May 25, 1976, EPA Administrator Russell C.

Train espoused conservation of the Chesapeake Bay with the following statement:

> The Bay is involved in--or affected by--the everyday lives of more than 8 million people who live and work and enjoy the good life in this region. As our nation's largest estuary, it is an economic, recreational and natural resource of priceless value. Even if one considers nothing else, the importance of maintaining the vitality of this great body of water becomes apparent just by looking at the role of estuaries as a fishery resource. It is estimated that about two-thirds of the commercial and recreational fish and shellfish of the United States spend significant portions of their lives, or even their entire lives, in estuaries such as the Chesapeake Bay. Some 200 species of fish have been identified in the Chesapeake alone.

Train's statement formally initiated a "Chesapeake Bay Water Quality Study," which proceeded under the auspices of the Chesapeake Bay Program. The Administrator divided the Bay study into three distinct management phases. The first phase involved organizational initiation and planning; the second phase concentrated on implementation of research; and the third phase included monitoring and Bay management. Committees guided the Program, comprised of members from the Maryland Office of Environmental Programs (OEP), the Maryland Tidewater Administration, Department of Natural Resources (DNR), the Virginia State Water Control Board (SWCB); the Pennsylvania Department of Environmental Resources (DER); representatives from local governments; citizens; industry officials and EPA officials.

While the Chesapeake Bay Program was an intergovernmental effort from the Program's inception, efforts were made to identify all entities with regulatory responsibility for the Bay. In specific areas the CBP coordinated programs of the U.S. Geological

Survey (Potomac River Study), U.S. Army Corps of Engineers (Chesapeake Bay Study), the Department of Commerce through the National Oceanic Atmospheric Administration (NOAA)/National Marine Fisheries Service, and work by the U.S. Fish and Wildlife Service.

2.5 LESSONS LEARNED

The formation of the Chesapeake Bay Program and its successful completion with the formulation of management alternatives indicates that a coordinating unit was needed for the Chesapeake Bay. An organization tasked with gathering data, sponsoring research, and testing management alternatives can be realized only through a cooperative effort with adequate resources, both in funding and personnel.

Public records, such as newspapers, speeches, and Senate Report 94-325, indicated shortcomings in the water quality monitoring of the Chesapeake Bay. Prior to 1977 a lead organization responsible for identifying research and assessing the state of the Bay was nonexistent. In an area experiencing steady population growth and land-use changes, such as the Chesapeake, perception of management needs also change. While individual states and institutions made significant efforts to address Bay problems, each program had its limitations. The federally mandated program, unlike state and private institutions, had the resources to make a comprehensive study of the Chesapeake Bay possible. Studying a system as complex as the Chesapeake Bay as a complete ecosystem should be considered when attempting similar programs.

3.0 PHASE I: INITIATION AND PLANNING (1976 to 1979)

The chief concern during the first year of the program was establishment of an organization uniting the Bay community in decisions concerning water quality. Unfortunately, the process of unification lasted nearly three years. Lengthy reports were printed describing the organizations involved in Chesapeake Bay issues, but little was accomplished towards uniting them in a common goal--management of the Bay. Research areas were selected and program monies allocated without establishing how the research would be integrated and linked with trends and management solutions. Long before research was underway a citizens' program was awarded a grant to involve the public in CBP activities. While a prestigious organization was formulated on paper, the CBP Management Committee did not become a strong decision-making unit until 1979.

3.1 LOCATION OF CHESAPEAKE BAY PROGRAM OFFICE

Since the Chesapeake Bay falls within the jurisdiction of EPA's Region III (Philadelphia) office, this office was initially given responsibility for Program management. Program funding was divided between EPA Region III and EPA's Office of Research and Development (ORD) because it was a combined research and control program. Until January 1979 the Regional office had managed the program from Philadelphia. Subsequent to January 1979 the Program was given its own office located in Annapolis, Maryland, the center of the Chesapeake Bay region. This action was taken to improve efficiency and coordination among participating organizations. It was announced at a January 29, 1979 Senate hearing conducted by Senator Mathias, "The Coordination of Federal and State Programs Affecting Chesapeake Bay," before the Subcommittee on Governmental Efficiency and the District of Columbia. Establishment of the Annapolis CBP office fulfilled a commitment made by the Assistant Administrator for ORD and the Deputy Regional Administrator for Region III in testimony at this hearing. Contrary to their testimony, however, the CBP Office was never co-located with the Region III surveillance and analysis staff in their Annapolis Field Office (later renamed the Central Regional Laboratory) facilities.

Until January 1979 the Regional office had the responsibility for contracts, personnel, grants, and other functions which were critical to the early stages of the Program. Beginning in January 1979 ORD assumed joint responsibility with Region III for Program Management. The Deputy Director of the ORD Gulf Breeze Environmental Research Laboratory, Dr. Tudor Davies, assumed the role of Director of the Chesapeake Bay Program. An Annapolis Field Study Office reporting to the Office of the Director of the Gulf Breeze Laboratory was established in April 1979. Subsequent management changes occurred which transferred the CBP directorship to the ORD Narragansett Environmental Research Laboratory (ERL) in November 1979. In addition to reporting to Narragansett, Dr. Davies also reported to the Philadelphia Regional Administrator.

Because of ORD's past experience in directing similar research activities, this transfer was seen as an important change. The Narragansett ERL conducted research aimed at improving knowledge of the effects of pollutants on marine organisms and ecosystems and of the movement and alteration of pollutants within such systems. Information generated by the laboratory is applied in permitting decisions and enforcement actions and is used as a basis for developing more useful and defensible regulations. The CBP research program was placed in direct contact with the management agencies that were the basic users of the technical information derived from the research studies.

The Program was initially criticized for changing management mid-point in the study; however, improvements occurred in program supervision, in interaction with regional, state, and public interest groups, in program research and integration, and in meeting Congressional directives.

The success of the new location and new management was voiced by Merilyn Reeves, Director of Maryland's League of Women Voters, at the CBP's Third Annual Meeting (December, 1980):

> Citizens wanted EPA management of the Bay Program to be located on the Bay. They wanted continued high-level involvement with state governments. They wanted EPA to assign highly qualified professionals to the program. And they wanted the Congressional mandate to be carried out for a full 5-year program. The best part of the citizen demand was that they vigorously expressed them. There was a great outpouring of letters to Congress, governors, and EPA. Delegations of citizen groups went to Philadelphia to express their continued support for the program. They did not want just a research program, but a plan of action which would assist in environmental decision making and ensure the future productivity of the

Bay. That December 1978 battle yielded good results. An office was established here on the Bay. Dr. Tudor Davies was transferred to head the program. State jealousies and past mistakes were laid aside, and there seemed to be a strong commitment for meeting Senator Mathias's original goal in the most cost-effective, environmentally sound manner. We are now in this period of euphoria, proud of survival and with hope for the future.

3.2 ORGANIZATION AND STRUCTURE

Committees designed to coordinate prospective managers, policy makers, and scientists from many disciplines were developed during the first phase of the Program. These committees made up the organization of the Program, offering guidance to CBP staff and researchers. Appointing persons with decision making authority to these committees was the key to their effectiveness.

A Policy Advisory Committee (PAC) coordinated Program activities with federal, state, and interstate agencies. The PAC had final responsibility for the direction of the CBP. The PAC included the EPA Regional Administrator, Director of the Chesapeake Bay Program, Chairman of the Technical Advisory Committee, Chairman of the Citizens Steering Committee, and Governor designees from the States. Subcommittees supported the PAC, allowing for an integration of various groups and an interdisciplinary research approach. The subcommittees consisted of a Management Committee, a Technical Advisory Committee (TAC), and a Citizens Steering Committee (CSC). In order to complement CBP efforts, a representative from the Department of Army, Corps of Engineers, was designated as a member of the PAC.

The Management Committee was the next major unit beneath the PAC responsible for directing research upon which the PAC could base decisions. It was essential that Committee members be knowledgable of Bay issues, be able to make decisions, and be able to appropriately advise and guide the policy makers. The Management Committee initiated staffing plans for the CBP, established Program goals, objectives and priorities, reviewed budget proposals, and initiated grant and research projects. The Chairman of this committee served in a dual capacity as Director of the Program, guiding day-to-day operations. The Committee consisted of representatives from water programs in Maryland, Virginia, Pennsylvania, EPA, and the Citizens Program for the Chesapeake Bay, Inc. This cross section of Bay managers complemented CBP efforts by establishing a communication network essential for a cooperative atmosphere. Dr. Tudor T. Davies, Director of the CBP from 1979 to 1982, described the structure of the Management Committee in his presentation at the CBP's Third Annual Meeting (December 1980):

> We made a number of basic decisions or assumptions at the initiation of the Program. The first guiding principle for the study is the concept that the Bay itself is an entity. The water quality in the Bay responds to activities and stresses that originate in the drainage basin. Any change that occurs in the Bay is a response to changes in the drainage basin. Although there are major environmental and ecological fluctuations within the Bay system, the major, long-term trends are related to changes induced by man in the drainage basin. An obvious resulting decision was to treat the Bay and its drainage basin as a single system for study. Consequently, it was important to have a management organization that represented a basin wide perspective.

We established a management structure that represented some of the major decision-making agencies for water quality in the drainage basin.

The Technical Advisory Committee, which provided direction to the research portion of the study, reviewed and approved all research planning processes, designed an integration scheme for completed research, and initiated a quality assurance plan for research. The TAC utilized scientific work groups to integrate communications among research contractors. Members of the TAC consisted of senior EPA scientists from the Office of Research and Development.

The Technical Advisory Committee was the most crucial group during the first years of the Program. Because CBP was a newly conceived organization, in-house scientific experience did not exist. The CBP relied on top ORD/EPA scientists to guide research. These key scientists provided technical supervision, guidance, and training as the in-house staff evolved. Without this unique gathering of experts, CBP could not have accomplished its objectives. As reports from research organizations neared completion, it became necessary to hire in-house personnel for the daily tasks of integrating the research. During 1978-1979, the Technical Advisory Committee carried CBP through a major transition by providing CBP staff with much needed guidance. Since operating budgets were not sufficient to pay both in-house scientists and the travel required for TAC members, a senior ORD scientist (Dr. David Flemer, who had also served on the TAC) was assigned to Annapolis as Senior Science Advisor of the Chesapeake

Bay Program. This decision was extremely beneficial to the CBP. Dr. Flemer would become the only on-site EPA employee (scientific or administrative) to see the Program through to its completion. It was only through Dr. Flemer's continued presence in the Program that much of the integration of scientific results, Bay characterization efforts, and Bay-wide monitoring plans would be documented in the Program's final reports.

The EPA Administrator designed the "Chesapeake Bay Water Quality Study" to allow changes in Program administration during the three phases of the Program. After the Management Committee completed organizational aspects of the Program, an important shift in Program responsibility took place. The TAC Chairman became chairman of the Management Committee, merging strong technical and managerial expertise during the research phase of the Program. When research and final products were completed, TAC relinquished responsibilities to the original Management Committee tasked with implementation of the Program's monitoring and future Bay management recommendations.

A Citizens Steering Committee (CSC) conducted regular meetings informing interested citizens of the CBP, reviewed Program initiatives and reports, and provided guidance to the PAC. The CSC coordinated activities with other Bay citizen programs such as 208 Water Planning Programs, Coastal Zone Programs, and the Corps of Engineers. Membership for the CSC included eighteen citizens from Maryland and Virginia who represented the users of the Bay. Approximately four to five members rotated annually and were replaced with new members to ensure accurate and up-to-date views on Bay issues.

Much of the Program's early efforts were centered around public involvement. A Federal regulation required that CBP allocate five percent funding toward public participation (five percent was 250,000 dollars). Many organizations were encouraged to submit proposals, and the Citizens Program for the Chesapeake Bay, Inc. (CPCB) was chosen as the best qualified. The Citizens Program is an association of 83 Bay-related organizations formed in 1971. The organization includes a broad range of environmental, civic, and business groups. The widely known Chesapeake Bay Foundation (CBF), established in 1966, was also considered but was not selected because CBF was a member of the Citizens Program which represented it as well as other interests. The goals and objectives of the Citizens Program included the development of a Bay-wide constituency and the means to solicit, receive, and consider citizen input in the CBP decision-making process. The CSC relied heavily upon the guidance of the CPCB when making decisions, and a member of the CPCB served on the Management Committee, thereby ensuring public involvement in the direction of the Program.

The CBP Director also served as Chairman of the Management Committee guiding day-to-day activities and ensuring that committee directives were carried out. When the Program was reorganized in 1979, in-house CBP management was assigned to the Deputy Director, Mr. Thomas B. DeMoss. The CBP Director and

Deputy Director established work groups for research study areas. Two distinct mixtures of personnel evolved over the course of the Program. During the first three years (1976-1979), Region III assigned program planners and managers to organize the Program structure. Technical support was provided through ORD staff serving on the TAC. With organizational arrangements completed and the office established in Annapolis, ORD assigned a staff of six program planners to Annapolis in 1979 to monitor research on a daily basis. In the capacity of Project Officers, these ORD personnel developed time lines, established accountability mechanisms and served as work group coordinators in specific topic areas. A few of the more aggressive program planners who demonstrated strong leadership and technical skills moved into research areas, demonstrating that upward mobility was possible in the Program.

3.3 STATE PARTICIPATION

The States participated in the Program through management grants funded by the CBP. Participating state agencies identified an office responsible for interacting with CBP staff, serving on work groups, managing Bay Program projects, and coordinating with other state agencies and offices. In addition, state officials served as members of policy committees.

Nearly 64,000 square miles of territory drain into the Chesapeake from the States of Maryland, New York, Pennsylvania, Virginia and West Virginia. Maryland's and Virginia's contiguous land locations within the Chesapeake Bay estuary made its active involvement with the CBP essential from the Program's inception. Because the Susquehanna River is the largest single contributor of freshwater into the Bay, and because most of the Susquehanna drainage basin is contained in Pennsylvania, a need for Pennsylvania's involvement became imperative. As early as 1979, the CBP staff began negotiations with the Pennsylvania Department of Environmental Resources and the Susquehanna River Basin Commission. Proceedings of the December 1980 CBP Second Annual Workshop indicated an increasing need to update Pennsylvania officials on recent Program facts and findings. The State realized its significant role in managing and improving the water quality of the Bay and became an active participant.

EPA promoted state involvement in every step of the CBP decision-making process. State participation was only possible through EPA grants which enabled funding for Chesapeake Bay offices within state agencies. For the first time research was coordinated between organizations and states which were once divided on issues requiring study. Funding enabled officials and staff within State agencies to participate in meetings and to serve as members of committees guiding CBP research.

3.4 PROGRAM FUNDING

Congress initially requested EPA to reprogram $25 million and fifty positions for the Bay Program. However, changes in Administrators and rearrangement of EPA priorities created problems for the Program. While Russell C. Train viewed the CBP as a regional program with national significance, the succeeding Administrator did not view the Chesapeake Bay as a high priority national problem.

The significance of the Bay as a national resource can be seen from looking at statements such as this by George Alexander, the former Director of Great Lakes Studies and a Texas lawyer.

> As far as the Chesapeake Bay is concerned, I would have to say that we in Texas, even though we have fairly adequate sources of good seafood, still rely on the Chesapeake Bay for many of the seafoods which we partake. So we do have an interest in your Chesapeake Bay.

As previously mentioned, the Program was originally conceived as a five-year study concluding at the end of fiscal year 1981. The Program was supported by two separate appropriations: abatement and control, administered by Region III; and research and development, administered by ORD. In addition to problems caused by changes in administration, zero base budgeting was implemented in 1980 and budgetary difficulties ensued from the Office of Management and Budget (OMB) and EPA policies. Instead of the five-year authorization, the Program was continued on a year-to-year basis. Unfortunately, this created an unstable environment at CBP causing excessively high turnover of CBP staff. High turnover coupled with understaffing problems from the outset (CBP received ten positions instead of fifty) caused administrative delays and missed deadlines. The Program required three one-year extensions in order to finish products. Debates involving funding levels for CBP created uncertainty about budget ceilings and made CBP decisions in awarding research grants difficult. The CBP was forced to rearrange research priorities and schedules. CBP personnel administered funding on the theory that next year's budget might be diminished. Without question, some decisions regarding funding of research projects and levels of funding would have been different, if the operating money was guaranteed.

3.5 PHASED MANAGEMENT APPROACH

In 1976, a phased management approach was adopted in administering Program goals. Initially, a five-year plan was prepared but was vetoed by committee members due to the uncertain outcome of the research. While Program objectives as outlined by Congress remained the same, the phased approach allowed flexibility in changing priorities, setting new directives and phasing in additional research as the Program developed new information regarding the Bay. This approach proved especially useful in 1980 as research began to peak. Integration of the research involved several steps that were not realized until work groups analyzed projects and preliminary findings. For instance, a need to segment the Bay into similar physical and hydrologic characteristics was determined late in 1980. (Segmentation is described in detail in Section 4.3.4 of this report.) The ability to phase-in this necessary step helped to accomplish a water quality classification scheme for the Bay based upon segments.

One consequence of the phased management approach was that Program results were developed as four major reports.

3.6 HOW RESEARCH WAS SELECTED

There was much concern early in the Program that the Chesapeake Bay Study would be "just another study." Letters were plentiful protesting the lack of action regarding Bay management. Typical are these statements by the CPCB:

> We just do not need another base study of the Bay at this time. . . We need a comprehensive management program, including both maxi-(government) and mini-(citizen) phases of problem-solving. In the former we have seen mostly self-perpetuating activities; in the latter, oversight by citizens have given direction and practicality to many programs.
>
> We hope that you will nudge the EPA Chesapeake Bay Program in the direction that you and Congress intended without the waste, delay and public irritation of duplicating work well under way. (5/10/77 letter from CPCB President to Sen. Harry Byrd, D-Va.)

In April 1977 the director of the University of Maryland's Center for Environmental and Estuarine Studies wrote Senator Mathias expressing dismay that the CBP was lagging behind schedule and not addressing its mandate. He suggested that a brainstorming session be held at the upcoming Bi-State Conference to put together a work plan for the CBP. The April 27-29, 1977 Conference, partially funded by CBP, was certainly a blessing to the future direction of the Bay Program. The Conference was an assembly of scientists, administrators, and interested groups and individuals whose opinions and activities the EPA was directed to coordinate. The Conference reviewed what was known about the major problems affecting the water quality and living resources of the Bay and what management implications could be drawn from these conclusions.

Several other agencies were vital players in identifying research areas. The Corps of Engineers was consulted during the planning stages to determine shortcomings and gaps in their recent study. In 1965, Congress instructed the Corps "to make a complete investigation and study of water utilization and control of Chesapeake Bay basin . . . including navigation, fisheries, flood control, control of noxious waste, water pollution, water quality control, beach erosion, and recreation," and they were authorized to build a physical, hydraulic model of the Bay. The Corps produced a seven-volume Existing Conditions Report in 1973 and a twelve-volume Future Conditions Report in 1977. The model proved useful for a number of flow studies, but funding for its operation was withdrawn in the spring of 1983. The Corps' study was criticized for a number of reasons: it was too comprehensive; it was not well-coordinated with State agencies of Maryland, Virginia, and Pennsylvania; it did not adequately consider the entire Bay drainage basin; and the Corps was not the Agency responsible for developing fisheries or water quality recommendations. Additionally, much concern was raised about the Corps' authority for the Bay when the Corps proposed to deepen Baltimore Harbor and dispose of the contaminated sediments at the popular fishing grounds of Hart and Miller Islands.

State agencies in Maryland and Virginia jointly prepared a program for research study. Other organizations, such as CPCB, encouraged the CBP to develop research needs. Another helpful source was a study by the Water Resources Research Center at the Virginia Polytechnic Institute citing citizens' attitudes about the Bay.

The CBP committees worked together in analyzing and outlining research needs and objectives. At an October 1977 workshop in Ocean City, Maryland, CBP participants analyzed all lists and identified ten critical areas for study. Three of the ten areas were selected to receive high priority attention and the seven remaining areas were given medium to low ranking in order to maximize available funds.

High Priority
- Submerged Aquatic Vegetation (SAV)
- Eutrophication (nutrient enrichment)
- Toxics accumulation in the food chain

Medium Priority
- Dredging and dredged material disposal
- Shellfish bed closures
- Fisheries modification (biological resources)
- Hydrologic modification

Low Priority
- Wetlands alteration
- Shoreline erosion
- Water quality effects of boating and shipping

In addition to SAV, nutrient enrichment, and toxics accumulation, a management study was selected as a fourth area for major study. Data gathering and research integration encompassed all ten research areas. For instance, investigators could not study SAV without looking at the entire ecosystem. Through synthesis of research and characterization of the research with data, scientists were able to link the decline of SAV with light and herbicides. SAV declines affected biological resources, wetlands, and shoreline erosion.

Overall, the three major research areas were wisely chosen because many areas of concern overlapped with these three. However, there are those who say it fell short by eliminating a study of a specific Bay species such as the oyster, blue crab, striped bass, etc. This would have been extremely useful when characterizing the Bay, a decision made in 1980. The purpose of characterization was to link water quality with resources, thereby establishing cause and effect relationships.

An excellent summary of the various research recommendations is contained in the "Virginia and Maryland Chesapeake Bay and Coastal Areas Briefing Paper," dated August 1979, prepared by the Virginia Office of the Secretary of Commerce and Resources and the Maryland Coastal Zone Unit, Tidewater Administration, Department of Natural Resources.

3.7 LESSONS LEARNED

The CBP identified five research objectives to guide research. However, it was not until after the 1979 reorganization that extensive, specific, in-depth questions were compiled. Without the specific questions researchers had no way to guide their projects toward addressing common concerns. The initial questions which guided the research follow. Specific questions are described in Section 4.3 of this report.

What is the current state (health) of the Bay?

What might be the future state of the Bay under certain growth scenarios?

How would you monitor changes from the current state of the Bay conditions?

What management control options exist to meet certain states of Bay conditions?

What are future research needs for the Chesapeake Bay?

The CBP recognized that there were major environmental problems that required immediate investigation. The methodology used to identify a number of priority areas originated from lists submitted by the various groups involved in meetings and discussions mentioned earlier. These lists were scrutinized in great detail as outlined below:

1. Major, easily identifiable research needs were determined. Submission lists and project lists were obtained.

2. Review of source lists allowed identification of major topic areas.

3. Detailed review of source lists provided need identification by topic.

4. Identified needs by topic were compared to source submission lists to determine multiple sources for each need.

5. Priority needs by topic (those having the greatest number of source requests) were compared to identify complementary needs.

The first priority of the Program was to select research areas. The Program's first priority should have been to develop a detailed list of questions. The management study raised important questions regarding the causes and sources of problems, but they were raised too late in the Program, not until 1979. These questions would have more effectively guided the research.

Instead of limiting program goals to merely completing 40 research projects and data collection, the phased-management approach provided an opportunity to periodically assess the progress of research and integrate findings toward describing the state of the bay.

4.0 PHASE II: IMPLEMENTATION OF RESEARCH (1979 to 1983)

Research essentially began with the reorganization of the Chesapeake Bay Program in 1979. The newly appointed Director, Dr. Tudor T. Davies, was an experienced manager of water quality studies through his affiliation with the Great Lakes Study. Dr. Davies was cognizant that under the Congressional mandate less than three years remained to complete research and develop management alternatives for the Bay. Results were attained through utilization of existing committees, peer reviews, an outreach program designed to involve user groups, and establishment of effective management tools which guided the research toward specific objectives.

4.1 PLANS OF ACTION

At a planning meeting held in Ocean City, Maryland in 1977, three distinct study plans were implemented for the Chesapeake Bay Program:

"Plan of Action--Toxics Accumulation in Food Chain," prepared by the Toxics Workgroup.

"A Plan for Ecological Studies of Submerged Aquatic Vegetation and Associated Living Resources of Chesapeake Bay," prepared by the Submerged Aquatic Vegetation Workgroup.

"Eutrophication Program for Chesapeake Bay," prepared by the Eutrophication Workgroup.

These Plans were circulated to major institutions, universities, and government agencies involved in Bay research to solicit their participation. The Plans of Action encompassed literature reviews, accumulation and evaluation of available data, extensive sampling in the Bay, analyses of the samples, experimental laboratory work, and management tasks. The sampling and analytical activities described in the various plans were designed to partially overlap. Sampling events were combined whenever possible for the sake of economy, to reduce duplication of efforts, and to obtain concurrent data for facilitating interpretation and modeling.

4.2 ANNUAL MEETINGS

Perhaps the singlemost important contribution to completion of the Bay study was the effectiveness of open communication. The importance of cooperation among the multitude of Bay organizations was emphasized at the Congressional hearing in 1979 and followed with extreme attentiveness. Annual meetings proved to be an excellent method for bringing individual elements of the Program together and reassessing program objectives. The monumental advancements made at these meetings deserve recognition. The meetings described in this section focus on workshops and events after the reorganization of 1979.

4.2.1 Second Annual Workshop

The CBP's Second Annual Review Workshop conducted November 27, 28 and 29, 1979, in Hampton, Virginia, was attended by over 250 people. Unique to this meeting were the separate reviews of the CBP conducted by the Scientific Review Panel (selected from outside EPA), the Technical Advisory Committee, the Citizens Steering Committee, and individual citizens. These reviews were directed both at the overall CBP and at individual projects and project tasks. The reviews generated comments and criticisms that helped define the Program direction during its remaining years. The Second Annual Workshop provided an opportunity for all participants to understand more fully the scientific projects and management efforts. At the same time, outside scientific peer reviewers could critique research and program direction and offer suggestions for meeting the CBP's goals. In addition, the workshop provided an opportunity for work groups in the three research areas to discuss ongoing research. Comments were extremely beneficial and resulted in major actions by the CBP. A need for integration of research was the most critical observation made by the outside peer reviewers. Their comments changed the direction of the entire Program from a solely research orientation toward integration and answering managers' questions. The Management Committee had this to say about the Meeting:

> It is our opinion that the Second Annual Workshop was a success because those who attended were able to sit back and review the entire Chesapeake Bay Program as well as gain a greater understanding of the highly technical projects. The Workshop proved extremely valuable as new

ideas were generated from all facets of the Bay community. The comments resulting from the Workshop and all the corresponding responses have contributed to making the efforts of the CBP more responsive to management needs.

Perhaps the most startling revelation of the Second Annual Workshop was the lack of basic knowledge by the average citizen concerning the Bay ecosystem. As principal investigators presented abstracts of their research, citizens were uncertain how the projects related to Bay ecosystem concerns. The Scientific Review Panel observed the questions being asked and recommended preparation of a base document which would educate the non-scientist on the Bay ecosystem. The CBP staff prepared "Chesapeake Bay: An Introduction to an Ecosystem," a publication well received by the Bay community. In less than two years, over 10,000 copies were distributed to Bay citizens and the publication is currently in its third reprint. One and two page briefs and summaries describing the complexities of the research in non-technical terms were also prepared.

The Technical Advisory Committee functioned at the Second Annual Workshop in a peer review capacity. By listening to principal investigators, comparing projects, and addressing questions, they determined final research requirements. The last major research grants were awarded early in 1980 and were geared toward strengthening the link between management and scientific research as identified at the Second Annual Meeting.

The Scientific Review Panel made critical comments at the meeting which resulted in a major directional change of the CBP.

The Panel pointed out the need for an integration of all research to characterize the state of the Bay. To respond to the Scientific Review Panel's concern, CBP organized a meeting of principal investigators in Wallops Island to influence how they would write their final reports.

4.2.2 Wallops Island

The Wallops Island Research Team Meeting was held May 11 to 13, 1981. The meeting was attended by the principal investigators of CBP projects plus CBP staff. The meeting emphasized the synthesis of research results. Each Workgroup - toxics, SAV and eutrophication - addressed this issue by developing a preliminary outline for a synthesis paper in each area. These outlines formed the basis for one of the major CBP reports, "Chesapeake Bay Program Technical Studies: A Synthesis," which was published in September 1982. Another topic discussed was the development of criteria for characterizing the state of the Bay. Also finalized at this meeting was a timetable for completing CBP projects.

4.2.3 Third Annual Meeting

The Third Annual Meeting of the CBP at Cross Keys Inn, Baltimore, Maryland, on December 1-2, 1980, focused on science and its management implications. The Congressional mandate directed the Program to assess the adverse factors affecting the health of the Bay and to recommend management solutions to mitigate stresses. Since the research was in final stages, it was natural to link management concerns with the research findings.

Two guest participants were invited from recently completed water studies--The Thames River Authority and The Great Lakes Water Quality Study. CBP Director Dr. Tudor Davies and Deputy Director Mr. Tom DeMoss had recently participated in an environmental conference sponsored by the NATO Committee on the Challenges of Modern Society. There they discussed pilot water quality studies with participants from other Nations and solicited the counsel of Dr. Peter Casapieri, Directorate of Scientific Services with the Thames Water Authority. Dr. Casapieri spoke at the Third Annual Meeting about the Thames Water Authority, which is responsible for overall water study, water quality management, and public accountability. CBP participants were able to ask questions about the United Kingdom's Water Act of 1973. The Act transferred duties previously exercised by a large number of authorities into a single authority with total control of all water programs. Successes and failures in their program were scrutinized by CBP managers.

The Great Lakes Water Quality Agreement of 1972 was discussed by George Alexander, former director of the Great Lakes study. The CBP asked questions about the Great Lakes long-term monitoring program and its management structure. George Alexander emphasized the need to "look at a type of structure that will allow all of the parties that are eventually going to have to implement to be involved in making the recommendations on what you are going to implement."

Both speakers provided valuable insight into broadening and refining management approaches to Bay findings. The states and citizens organizations added their perspectives on Chesapeake Bay Management at the Third Annual Meeting. The CPCB listened to comments regarding the education of the public and the need to integrate the proper mix of Bay users in the decision-making process. Fran Flanigan, Director of the Public Participation Program for CPBC responded:

> This coming year we have decided to target our efforts on selected groups who we know have an interest in the Chesapeake Bay. There are associations and groups of people who already have a viewpoint that we feel need to be brought into the Bay Program....We are going to focus this year on reaching specific interest groups, agricultural groups, seafood-oriented groups, the business community, and the environmental interest and public interest groups who have for such a long time been interested in the quality and future of the Bay.

4.2.4 Donaldson-Brown Workshop

A three-day workshop was held March 5-7, 1981 at the Donaldson-Brown Center in Port Deposit, Maryland. After the Third Annual Meeting held in December 1980, principal investigators and CBP staff reviewed and revised the draft synthesis papers and attempted to answer the management questions as refined at that meeting. Citizens and scientists alike watched the fruits of their research efforts come together. Briefs and summaries describing management implications were written for each completed research project. The non-technically composed briefs were distributed by CPCB to concerned citizens, apprising them of scientific findings requiring their future action.

A Management Committee meeting during the Donaldson-Brown workshop evolved the CBP into a new phase. It was apparent from discussions with the researchers during the three-day workshop that the individual project reports provided a description of the research, but until the findings were linked with water quality trends, no cause and effect relationships could be established. Consequently, a new priority emerged to try and link water quality research with Bay resources.

4.3 MANAGEMENT TOOLS USED TO DIRECT RESEARCH

4.3.1 Management Questions

Management questions were prepared by the CBP staff in 1979 and peer reviewed by CBP committees. These questions were related to the three research areas of highest priority--nutrient enrichment, SAV and toxics. The questions were designed to answer the concerns that precipitated the CBP in 1976, and served to direct CBP research throughout the remainder of the Program. By outlining specific questions which needed answering, principal investigators geared their research toward common objectives. The management questions, and their answers developed by the CBP, are contained in "Chesapeake Bay Program Technical Studies: A Synthesis," pp 6-35.

Development of the management questions involved three steps. Initially, the management questions were reviewed by the CBP Management Committee, all Work Groups, EPA ORD and Regional personnel. This ensured that all key actors--federal and state managers and citizens--agreed upon the management questions to be addressed. Research teams, composed of the CBP staff and principal investigators, refined and developed more detailed research questions for each of the management questions. Secondly, as soon as the specific research questions were ready, they were distributed to CBP principal investigators. The principal investigators were directed to answer questions pertaining to their particular study within the context of their final reports. In most cases, information from more than one study was necessary to answer a specific research question. Research teams composed of CBP staff, key principal investigators and state personnel pulled together responses from the project reports, as well as relevant literature information, and prepared scientific monographs--one per research question. Finally, CBP staff arrived at a set of working papers which answered the management questions by analyzing the answers to the research questions, synthesizing them, and drawing conclusions. These papers were used in preparing the drafts of the final program reports.

The CBP realized that it would not be able to answer all the research questions, nor would it be able to be as definitive in some as in others. The CBP conducted an honest evaluation of available information and came to conclusions in each program area. The philosophy of CBP research and management recommendations originated from these questions; that is, don't wait for the ultimate scientific experiment. Make sound choices on the information in front of you now.

The importance of the management questions in directing the scientists cannot be over-emphasized. By using the management questions prepared by the CBP staff, the researchers had specific goals. The CBP was obligated to answer, to the extent possible, the damage caused by excess nutrients, what had caused the decline in SAV, and the extent to which the Bay was contaminated with toxic chemicals. The management questions forced the scientists to step out on a limb by using the best information available to report not only their research findings, but also how these results reflected past utilization and management of the Bay and its watershed.

4.3.2 Quality Assurance

The scopes of work contained in the three Plans of Action (see Section 4.1) were performed primarily by grantees whose data formed the input for the CBP final products. The precision and accuracy of their data were imperative, since management decisions concerning the Bay are only as good as the quality of data upon which they are based.

A comprehensive data collection and research quality assurance (QA) program entitled "Quality Assurance for the Chesapeake Bay Program" was developed for CBP. The EPA Environmental Monitoring and Support Laboratory (EMSL) in Las Vegas, Nevada, developed sophisticated guidelines for assuring uniform quality control on all data collection activities. The EMSL coordinated and served as a focal point for all quality assurance activities including:

Assisting grantees in identifying and coordinating methods and quality assurance procedures.

Evaluating and coordinating the QA parts of all protocols.

Defining data acceptability for the various tasks and ascertaining uniform data reporting including variance estimates.

Providing or arranging for the provision of reference materials.

Conducting round-robin evaluations and intercomparison studies as needed to evaluate analyst skills and methods adequacy.

Through EMSL's guidance, CBP ascertained that all grantees used standardized or comparable procedures in their activities: sampling, sample preservation, handling and storage of samples, sample analysis, reference methods, instrument calibration routines, use of reference materials, duplicates, blanks and split samples, chain-of-custody procedures and record-keeping. The EMSL made available biological reference materials for distribution to analytical laboratories involved in the program, such as fish solubles, oysters, copepod homogenate, animal blood, animal muscle, bovine liver, animal bone, and leaves. These materials were certified for a variety of stable elements at environmental levels.

Intercomparison programs were conducted by various EPA laboratories. Grantees were encouraged to participate in respective programs to demonstrate the comparability and compatibility of analytical data between participating laboratories.

The CBP/EMSL quality assurance plan can be broken into three distinct parts:

Project specific QA requirements.

Standard documentation and procedure requirements applicable to sampling activity and laboratory analyses.

Model verification and calibration process.

A fourth area of quality assurance, peer review, was established by CBP and EPA/ORD. Peer review is described in Section 4.3.3 of this report.

The EMSL referenced literature, where appropriate, of specific guidelines for researchers, i.e., "Manual of Methods for Chemical Analysis of Water and Wastes" (EPA 625/16-74-003). Other EMSL services included the design of checklists to assist investigators and project officers to assess the adequacy of their internal and external controls.

CBP project officers were required to conduct periodic on-site reviews of each facility. The project officer's evaluation enabled the CBP director and deputy director to provide guidance where necessary and a status of on-going research.

4.3.3 Peer Review

Throughout the Program, peer review was implemented to ensure that the best possible products were developed. The scientists called upon to review reports responded by focusing not on the best aspects of the science, but upon its weaknesses. Such an approach caused delays by requiring additional work by researchers, editors, and other staff, but resulted in high quality products. Peer reviews were conducted at many levels and facets of the program. For instance, trimester meetings were organized where researchers met and discussed status of research. Then, once a year at annual meetings, researchers presented their findings to all committees and organizations associated with CBP. Finally, their final reports went through a formal peer review process, established by EPA regulations. The four in-house CBP final reports underwent the same type of review. The one difference was in the informal review: instead of trimester meetings, there were weekly work group meetings, headed by the Deputy Director. Through these meetings, staff interrelated on problem areas, discussed findings, and established time schedules. As CBP Deputy Director Thomas DeMoss noted:

> I needed to know when to expect a product--in a day, a week or a month. Without an estimated time, I would have no way of quessing an end product. By holding the staff accountable to those deadlines, I was able to push for a completed product. Often, unforeseen problems arose and deadlines were moved. But, a new deadline was always imposed, thus, driving research toward a close. Congress did not intend for the study to go on forever. (Interview)

After staff completed work, workshops were set up to discuss their findings. Final peer review at the state and federal level transpired for all reports.

As an example of the intensity of peer review, a summary of the review process for the CBP report, "Chesapeake Bay Program Technical Studies: A Synthesis," is detailed below. Although the synthesis papers were written by separate authors, the contents of each paper were arranged within a format of management questions developed by the Management Committee, CBP staff, CBP working groups, scientists, EPA Headquarters, and Region III during the fall of 1980 and winter of 1981. In the spring of 1981, authors for each paper submitted outlines to CBP addressing those questions. Each paper integrated or synthesized information from CBP-funded research and from other sources relevant to the papers. During the summer of 1981, authors wrote drafts of their papers which were tracked by technical coordinators at CBP. The papers were presented at Management Committee meetings in July and August 1981. Authors explained the purpose of the papers and progress to date.

On September 15, 1981, completed drafts were mailed to two peer reviewers and state manager/scientists. In mid-October 1981 authors met with CBP staff to discuss peer and state review comments and incorporate changes. Final drafts were submitted during December 1981. In early January 1982 finished papers were mailed to the states and in February further technical issues, together with the tone and format, were discussed. In early May 1982 the synthesis papers were sent to Region III, state representatives, and citizens for a final policy review. On June 17, 1982, these groups met at the CBP office to discuss those comments. The papers were also mailed to the authors for final suggestions and approval. Until the end of July 1982, as many technical and policy changes were made as possible. The final product, "Chesapeake Bay Program Technical Studies: A Synthesis," was given to Region III in early August 1982 for printing.

4.3.4 Segmentation

Consultation with authorities from other water programs reaped many benefits for the CBP. The basic concern of Bay scientists was that large ecosystems are too diverse and complex to either study or manage as one unit. For comparative purposes, it became important to understand the components of the estuarine system in terms of their interaction. A framework was required permitting the estuarine ecosystem to be divided into comparable units from an analytical perspective and to represent the continuity of the system process. Segmentation was such a framework.

The Thames River Authority, the Great Lakes International Joint Commission, the San Francisco Bay Authority, and others had developed systematic methods to segment water bodies into sub-units based upon physical, chemical, and biological parameters. Participation in the 1980 Committee on the Challenge of Modern Society Conference helped the CBP to identify programs with similar characteristics to CBP. For example, the Thames River Authority divided the Thames into regions based upon physical, chemical and biological parameters. Scientists and managers then assessed trends to characterize the condition of each segment with respect to water quality objectives. Planning agencies for the Great Lakes divided the lakes into zones with similar nutrient and chlorophyll a levels to monitor eutrophication. The proven success of segmentation in the Thames estuary and the Great Lakes freshwater system indicated that segmentation might be a useful step in studying the Chesapeake

Bay. Segmentation did, in fact, influence most aspects of CBP research. Research was identified, data were categorized, and modeling efforts and management alternatives were developed using segmentation.

Before adopting the segmentation approach, CBP consulted with expert scientists who professed the concept of segmentation. Dr. D. W. Pritchard had outlined his philosophy at the Chesapeake Research Consortium's RANN Waste Water Program. Dr. Pritchard offered several refinements to CBP's segmentation approach. In 1974, R. E. Ulanowicz and B. J. Neilson implemented Pritchard's proposal by devising a successful segmentation scheme for the Patuxent and Elizabeth Rivers. They chose physical processes, as opposed to biological, to segment boundaries since the physical-chemical environment determines the nature of the biological community inhabiting that environment.

A CBP Segmentation Task Force was established in December 1980. The Task Force assessed these various approaches and developed a sophisticated approach for the Bay to arrive at 45 individual segments. The segments were used as a framework to map and analyze past, present, and future conditions of Chesapeake Bay.

The main criteria for segmentation of the Chesapeake Bay were based upon geophysical conditions since these factors set the boundaries for chemical and biological conditions. This was explained in a CBP paper entitled "Trends in Water Quality for Chesapeake Bay Relative to Improved Management":

> Salinity and hydrographic structure are useful parameters since salinity is widely recognized as a key parameter in determining the nature and extent of biological communities and the hydrographic structure characterizes the potential for materials (e.g., nutrients, dissolved oxygen, and toxic chemicals) and organisms (e.g., true plankton, eggs, and larvae of numerous Bay fishes) to be transported in the system ... thus, a first level of analysis might lead to segments that correspond to the following classification: tidal freshwater, turbidity maximum, region of two-layered circulation, etc. Each of these regions shows similar dominant biological features, e.g., the tidal freshwater is the spawning area for several anadromous fishes and when under excessive nutrient supply, responds with "nuisance" blue-green algae . . .

Segmentation of the Chesapeake Bay had many benefits. It provided a method to measure resource use changes over time as related to water quality variables. It established bases upon which to evaluate control programs (both technical and administrative alternatives) and water quality objectives. It provided a picture of the Bay with regard to toxic pollutants, nutrients, and Bay grasses. It was employed with other systems to project the future state of the Bay. It helped identify additional areas where research is still needed.

4.3.5 Modeling

In recent years, modeling has become an effective management tool for predicting potential future effects for a body of water. Not only do models offer the manager an understanding of the short- and long-term conditions which contribute to degradation, modeling can also shed light on the spatial extent of water quality problems. Mathematical modeling can show, for example, which river basins and watersheds contribute the greatest quantities of nonpoint pollution into the Bay. This prediction tool allows policy controls to be tested before they are implemented.

Since the field of water quality modeling is new and considered somewhat of an art, the decision as to which model to choose was a most difficult one. Several physical models were already operational. The U. S. Army Corps of Engineers in Matapeake, Maryland, developed a physical hydraulic model of the Bay which scaled depth, width, and length. The model, a large concrete replica of the Bay, was used to evaluate freshwater flow on the circulation pattern of Bay waters, but was limited by lack of wind and storm conditions. On the other hand, sophisticated computer models simulate the effects of wind associated with storms, as well as changes in ecological parameters such as dissolved oxygen and nutrient levels.

Bay scientists and managers sought a model which would provide information on the chemical variations in the Bay. Such an understanding would provide the key to the movement of freshwater into the estuary, and thus transport of sediment and other pollutants. With increasing loads of nutrients entering the system from various sources, it was of paramount importance to understand existing eutrophication conditions in relation to future trends. Planners wanted to look beyond measured field data and establish cause and effect relationships that explained water quality. Mathematical models were the answer to these large demands.

Given the time constraints for completion of the study, CBP felt that they could not wait for completion of the research and data gathering to begin modeling efforts. When the decision was made to begin modeling (1980), there was thought to be less than one year left until the Program's end (1981). Little did CBP realize that two one-year extensions would be granted for completion and analysis of results. Like the research itself, it was hoped that integration of the modeling efforts would be possible with time. Two types of state-of-the-art mathematical models were identified as giving the most rapid, accurate predictions for the Bay. These were a watershed model for estimating nutrient loadings at the fall line and a tidal model for describing physical and chemical parameters downstream of the fall line.

The singlemost criticism of the CBP decision regarding the tidal model was that the model was chosen without intensive peer review. Since CBP was successful in quality assuring products through intensive peer review, failing to do so in such a new area was viewed by some with dismay. CBP managers, however, felt that under the existing time constraint of one year, they made the best choice by selecting a state-of-the-art model that had already been applied to Bay research. When the tidal modeling effort was finally peer reviewed in March 1983, it was judged unsuitable and the model results were never used by the CBP. The watershed model received high marks by the same review panel and this model was used by the CBP to develop fall line loadings for nitrogen and phosphorus.

4.4 CHARACTERIZATION

As mentioned earlier in this report, the CBP proceeded with the assumption that 1981 would be the last year of the Program. However, during that year research culminated, data gathering neared completion, and results of CBP findings surfaced. Researchers stood back and saw similar trends in their research. One CBP Management Committee member, Lee Zeni, from the Maryland Department of Natural Resources, Tidewater Administration, pushed for linkage of the research with the recently accumulated historical data. In essence, Mr. Zeni argued, the Program should not be just another water quality study, but should link living resources with water quality, making the CBP an environmental quality program.

The characterization effort drew on dozens of major Bay-wide water quality and living resource studies from the past thirty years. Since CBP did not originate as a living resources study, emphasis was not placed upon collecting resource data. To overcome this, state agencies pulled relevant data from their files for inclusion in the CBP data base and staff approached outside organizations in search of vital information. In most instances data were readily volunteered. However, some organizations not funded by CBP grants were reluctant to give their data to the CBP.

Segmentation eased the comparison and organization process of describing water quality trends. To characterize how water quality and resources changed over time, the CBP assessed plankton, SAV, benthic animals, and finfish. From 1981 to 1983, CBP staff collected and analyzed data (current and historic) from institutes around the Bay. Correlations were found indicating strong relationships between certain water quality conditions and the abundance of resources. The characterization report earmarked specific needs and reasons for monitoring strategies and control mechanisms in problem areas. The result of these efforts are described in a major CBP report published in 1983 entitled "Chesapeake Bay: A Profile of Environmental Change."

4.5 DATA MANAGEMENT

Data management refers to the collection of computerized mechanisms for storing, processing, and analyzing data. The need for Bay data management was voiced by Congress in 1975 when it authorized the funding for the CBP. The Senate Committee on Appropriations directed EPA to:

> analyze all environmental sampling data presently being collected on the Chesapeake Bay and to suggest and undertake methods for improving such data collection. The (Environmental Protection) Agency is also directed to establish a continuing capability for collecting, storing, analyzing and disseminating such data. (Senate Report 94-326)

This broad directive created a major challenge for the CBP which by the end of the Program had been only partially fulfilled.

The need to provide data management support was recognized by the CBP soon after the Program was moved in 1979 to Annapolis. In May 1979 an employee of the EPA Environmental Research Lab, Gulf Breeze, Florida, was transferred to the CBP as Automated

Data Processing (ADP) Coordinator. At about the same time, EPA brought to Annapolis on a part-time basis the Gulf Breeze Lab's senior statistical consultant. These two formed the initial data management team. Their transfer from Gulf Breeze was initiated by Dr. Davies, who had recently served as Deputy Director of the Gulf Breeze Lab. The Gulf Breeze Data Management Program was considered an acceptable model for the CBP because Gulf Breeze performed scientific research that was similar to the CBP, particularly in the areas of toxics in estuarine environments and submerged aquatic vegetation.

During 1977 CBP data management requirements centered on the 40 CBP-funded research projects. It was estimated that the needs of these projects plus computerization of Bay management data would generate the requirement for 45 to 50 million bytes of data storage. This is equivalent to approximately 600,000 computer cards.

In the summer of 1979 the anticipated data management users of the CBP computer included environmental modelers, contractor staff for data entry and program development, EPA administrators, and CBP grantee scientists. At that time it was thought that the scientists receiving CBP grants and contracts would organize and analyze their own data on the CBP computer. Similarly, the CBP in-house environmental engineers would organize their own data in support of the modeling effort. Little if any thought had been given to the need for the CBP to provide extensive data management support. This need became apparent, however, as the Program's emphasis shifted from initiating research to interpreting and synthesizing large quantities of data from many and diverse sources.

In August 1979 the University of West Florida's Institute for Statistical and Mathematical Modeling (ISMM) was awarded a cooperative agreement to provide the CBP with statistical support. This began a four-year association under which most of CBP's statistical and computer support were carried out. Dr. Jerry Oglesby, Director of the ISMM, managed this effort in Annapolis. Dr. Oglesby's prior role in the CBP was as a consultant. The cooperative agreement brought Dr. Oglesby into the Program as a manager. In addition, he continued to provide statistical and scientific support. The cooperative agreement also supplied additional researchers who, working in conjunction with EPA staff, developed the widely publicized CBP data base. The CBP data base would require the next two and one-half years to complete, and at CBP completion, would be considered one of the Program's most important products.

On November 27, 28, and 29, 1979, the Second Annual CBP Review Workshop was held in Hampton, Virginia. This workshop provided the data management staff with its first opportunity to gain an overview of the types and volume of data being generated by CBP grantees, as well as to learn in detail about the sampling plans, data collection techniques, etc., being utilized by grantee scientists. Each principal investigator presented the objectives, scientific approach, preliminary results, and anticipated products of his project. In addition, a milestone chart was developed for each project. These presentations were assembled into a report that became a primary reference document for data management planning.

The CBP data management planning effort during the fall of 1979 was matched by parallel efforts in Maryland and Virginia. Both states received funding from the CBP for data organization, technical support, and coordination. Under these projects both states developed procedures for entering and processing data via STORET (EPA's computer software system for the storage and retrieval of water quality data). CBP funds were used to hire data management staff, acquire terminals, and pay for computer usage. CBP data management staff trained state personnel in the use of EPA systems. In turn, the states assisted the CBP by entering data into STORET that had been collected by state agencies (e.g., 106 program data) as well as by CBP grantees.

During 1980 the CBP evaluated its data management program and arrived at the following conclusions.

1. Extensive statistical analyses were providing benefit to a few grantee scientists but were of limited benefit to the CBP.

2. Data from CBP-funded studies were not being delivered to the CBP on time.

3. Data from CBP studies were insufficient to characterize the Bay.

Contributing to the CBP's data management problems was a re-definition of the CBP's end goals. By the fall of 1980 the CBP's primary research objective was not only to sponsor research, but also to characterize the Bay's environmental quality. This objective implied a redirection in the Program's scientific activities to more strongly emphasize the integration and synthesis of data. The need to integrate data and combine research results created new demands on the data management program. In addition to merely storing and retrieving data from independent studies, the need now was to standardize and combine data sets into new units that could be used for comprehensive statistical analyses and scientific hypothesis testing. Clearly, the need for a unified holistic data base had emerged.

The problems of misdirected statistical analyses and missed due dates for data submission by CBP grantees required a major shift in the leadership role of the data management effort to resolve. Prior to 1980, data management was primarily defined as assisting CBP grantees as needed, with the level of assistance delineated by the grantees. During 1980 it was recognized that, given the diverse and autonomous group of institutions participating in the CBP, this management strategy would not result in the needed data base.

In April 1980 the CBP moved computer operation and computer systems responsibility from an existing computer contractor to the ISMM. The reason for this decision was that since the principal justification for the CBP computer was to process, analyze, and interpret CBP data, management of the computer should be under the direction of those responsible for these tasks. The result was a streamlined and more effective management mechanism. CBP Deputy

Director Mr. Thomas DeMoss began taking an active role in the data management program. Weekly meetings were held to discuss progress in acquiring data and building the data base. Extensive statistical analyses were discouraged in order to devote more time to development of the data base.

The problem of late data set submittal was solved by taking a more agressive tack. Rather than wait for data, the CBP decided to actively work with grantees to assure the timely delivery of their data. Data formatting requirements and storage media were discussed in meetings with study principal investigators and in visits with grantee scientists in their offices. In some cases it was possible to transmit CBP data directly from the research institution's computer to the CBP computer via phone line.

By the fall of 1980 the goal of characterizing the state of the Bay regarding toxics, nutrients, and SAV had been adopted by the CBP. At this time it was realized that the CBP would need data in addition to those generated by CBP-funded studies in order to achieve this goal. The data collection job confronting the CBP was stated by Mr. DeMoss at the December 1980 Cross Keys Meeting:

> First, we must look at the observed data that exist both in our program and outside. This will include literature searches and reviews of data bases from Bay institutions which have done, as you know, excellent work on the Bay for many years. We must not recreate the wheel. Another source of information is projected data from modeling work.

The data search articulated by Mr. DeMoss at the Cross Keys Meeting continued through the summer of 1982. The objective was to increase the spatial and temporal extent of the data base. The willingness of institutions to give data to the CBP varied. In most cases complete cooperation was given. In one instance, however, a well known institution receiving substantial federal funding turned down a formal request from the CBP. Data sets were provided on a variety of storage media. In some cases, the CBP keypunched data that had arrived in boxes of laboratory sheets. In others the CBP was given quality assured and well organized data sets on tape.

External data were combined with data generated by CBP-funded research to form the basis of the CBP data base. The final data base contains over three million observations. The principal data sources utilized are shown in Table 4-1. The CBP evaluated the suitability of various data base management systems for handling this vast amount of data. The following criteria were used.

1. The system must contain statistical and graphical analysis capabilities, or the system must be able to format the data base into a structure that can be utilized by statistical and graphical software.

2. The data base must be easily updated.

3. Data access and simple descriptive analyses and tabular listings should be possible by scientists who are not computer specialists.

4. The data base should be portable.

5. Complete data documentation should be possible within the system. Documentation should be stored within the data base.

6. The system should contain sophisticated data subsetting and merging capabilities.

7. The scientific validity and accuracy of the system's computational algorithms should be universally accepted.

8. There should be a large existing user community for the system.

These criteria were best met by the Statistical Analysis System (SAS). Consequently, the development of a SAS data base was initiated. SAS would be utilized via batch mode on EPA's IBM 370.

Table 4-1. Principal Data Sources for the CBP Data Base

Agency	Temporal Coverage	Data Base Description	Parameters
American University	Scattered years since 1936	Historical SAV aerial photographs	Vegetation distribution
EPA, Chesapeake Bay Program	1980	CRIMP, Taft	Temp., sal., D.O., flow, nutrients, Chl-a
	1977-1980	USGS, Fall Line	
	1977-1981	Helz, sediment	Heavy metals
		Nichols, sediment/water	
		National Bureau of Standards, sediment/water	
		USGS, sediment/water	Heavy metals,
		Monsanto, sediment/water	Organics
		Huggett, sediment/tissue	Organics
	1978-1979	SAV Aerial Survey (Quads)	Hectares of vegetation/quad
	1980	Bay Benthic Survey	Biomass and community composition
EPA, STORET	1961-1981	Water, Tissue, Sediment	Heavy metals, pesticides, organics
EPA, Annapolis Central Regional Lab	1965-1979 1965-1970	Main Bay Potomac	Temp., conductivity, D.O., BOD, secchi, Chl-a, nutrients

Table 4-1 (Continued)

Agency	Temporal Coverage	Data Base Description	Parameters
Chesapeake Bay Institute	1949-1980	Bay, River, Nutrient, AESOP, Special, Model, Whaley-Carpenter, Pro-Con	Temperature, salinity, D.O., pH, Chl-a, nutrients
Chesapeake Biological Lab	1970	Patapsco Benthic Survey	Biomass and community composition
	1978-1979	Calvert Cliffs Benthic Survey	
Fish and Wild-life Service	1971-1981	SAV Vegetation Survey	% vegetation coverage
Maryland Department of Health	1968-1980	Maryland Shellfish Sampling Stations	Fecal coliforms
	1970-1981	Haire--sediment	Heavy metals
	1971-1981	Eisenberg--tissue	Heavy metals, PCB's pesticides
	1966-1972	STORET/MD 106	Temp., sal., D.O.
	1973-1980		Temp., D.O., BOD, Ph, Chl-a,nutrients
Maryland Department of Natural Resources	1939-1981	Oyster spat set on natural cultch (MD)	Spat per bushel
	1963-1981	Oyster condition index (MD)	Rating of meat quality poor to good

Table 4-1 (Continued)

Agency	Temporal Coverage	Data Base Description	Parameters
National Marine Fisheries Service	1880-1981	Fisheries historical landings (Bay-wide)	Pounds
Virginia Bureau of Shellfish Sanitation	1964-1982	STORET	Fecal coliforms
Virginia Institute of Marine Science	1970-1980	Slackwater	Temp., sal., D.O., BOD, Secchi, Chl-a, nutrients
	1946-1981	Oyster spat set on natural cultch (VA)	Spat per bushel
	1955-1981	Oyster condition index (VA)	1) Index no. 3.0 to 7.6 2) Yield of meats per bushel 3) Rating below average to above average
	1973	Hampton Roads Benthic Survey	Biomass and community composition
Virginia State Water Control	1964, 1968-1980	STORET/VA 106	Temp., D.O., BOD, Ph, turbidity, nutrients
	1970-1981	Gilinsky--sediment and tissue, VA-106	Heavy metals, organic compounds

4.6 LESSONS LEARNED

A high degree of quality assurance was placed on the synthesis and characterization reports to ensure their credibility to the Bay community. Since the papers were one step towards development of management alternatives, the endorsement of Bay organizations was mandatory. Quality assurance originated during research gathering, as individual researchers adhered to the EPA/ERL-LV Quality Assurance procedures. The individual reports underwent in-depth peer review. The principal investigators synthesized the individual reports to answer management questions that had also been peer reviewed. In turn, the synthesis reports and characterization were given the same degree of scientific scrutiny as the reports they were based upon. The peer review process was very time consuming when considering CBP deadlines and the additional work it caused staff and researchers revising reports. However, when considering the complexity of the Bay ecosystem, the magnitude of the Bay community, and the long-range effects CBP recommendations would have on the fate of the Bay, extensive peer review is commendable.

The decision to synthesize and integrate the results of the CBP-funded and non-CBP data in order to characterize the Bay represented a major shift in direction for the Program. This shift enabled the CBP to utilize CBP research data more effectively by combining them for analysis and interpretation with a large amount of additional data. However, the decision to characterize the Bay should have been made earlier. This would have enabled research studies to be designed for the goal of supporting characterization. The inability of the CBP to show statistically valid causal relationships between living resources and water quality could be considered a shortcoming. However, since this was not an original CBP goal, many CBP watchers are reluctant to fault the CBP for this inability. A better evaluation of CBP effectiveness might be to assess the way in which the CBP was able to `develop management recommendations despite the lack of real causal relationships.

The decisions made to choose appropriate mathematical models and manage the water quality modeling effort are difficult to assess because the modeling results are still undergoing review and are the subject of much controversy. However, one of the fundamental objectives of the modeling effort was clearly not met. The CBP was unable to relate changes over time in fall line nutrient loadings to downstream nutrient concentrations. This relationship was needed to estimate the effect of alternative point and nonpoint source control strategies.

The development of the CBP data base is considered by many to be one of the Program's most important products. This was possible only due to the development and implementation of an effective data management plan and strong leadership in this area. The data management plan should have been developed much earlier; it should have been in place at the time CBP contracts were finalized. Because it was not, the CBP had little control over data precision, computer storage media, variable names, or data formats. This led to delays when the CBP began utilizing contractors' data.

An important lesson to remember when embarking on a similar project is to make the public aware of the system undergoing study. A document describing the intricacies of the ecosystem should be distributed for reference as soon as research is underway.

5.0 ESTABLISHING A FRAMEWORK FOR MANAGEMENT RECOMMENDATIONS

5.1 OVERVIEW

The Chesapeake Bay Program, from the very beginning, had a clear commitment to assure that the results and findings were both scientifically sound and implementable. Prior sections of this report have dealt with the history and processes relating to the research. This section deals with how those findings and recommendations were turned into action items for the states and the federal agencies. It also looks at steps that must be taken to assure that the implementation process continues forward.

5.1.1 Tools

Tools in this context are simply the collective knowledge of the condition of the Bay and its trends and processes. This statement of condition, or "state of the Bay," is primarily contained in the report "Chesapeake Bay: A Profile of Environmental Change." This report characterizes the Bay's present and historic condition for both biological and water quality parameters. It is the primary integration document that links water quality with resources and explains the changes that are taking place in the Chesapeake estuary. The report does not judge if a change is "good" or "bad" from a user perspective.

A second tool that was used to develop a scenario of action items was the watershed model. This mathematical model helped estimate loadings of nutrients from all nonpoint sources delivered to the fall line for each major tributary to the Chesapeake Bay. Data were available for nitrogen and phosphorus loadings under wet, dry, and average runoff conditions. These data, when combined with knowledge of point source effluent loadings, helped identify the river systems that contribute the highest percentages of nutrients to the Bay. This information helped to begin the process of developing recommendations for nutrient load reductions.

Using these two tools, CBP staff gained an understanding of the condition and trends in water quality and resources and the sources of nutrient loadings. The problem then became one of turning this understanding into a plan of action for improving Bay environmental quality.

It should be noted that the process of developing management recommendations did not go exactly as planned. Two major obstacles had to be overcome before this process could continue. The first obstacle was reluctance on the part of the scientific community (both within and external to the CBP) to state that there was a cause-effect relationship between the decline in water quality and the decline in biological resources. The second obstacle was the failure of the CBP modeling effort to accurately predict Bay circulation and the transport of materials downstream of the fall line. The two mathematical models designed to do this were judged unsound by scientific peer review and were never coupled to the watershed model.

The inability of the CBP to predict with engineering precision the consequences of alternative load reduction programs had a profound impact on not only how the management recommendations evolved, but the actual recommendations themselves. The imperative to overcome these two hurdles was reinforced by sustained public and political pressure to develop a firm action plan. The pressure to develop a plan, when combined with the scientific reality, led CBP managers to make three basic working assumptions.

There is a relationship between water quality and the biological health of the Bay.

Any reduction in nutrient loads will eventually benefit the water quality and also the biological health of the Bay.

The Bay should be managed on a regional watershed basis.

With these three working assumptions defined as CBP policy concepts, the process of developing management recommendations continued.

5.1.2 Goal Setting

Goal setting for the Chesapeake Bay was essentially a democratic public process that involved Bay users from a wide spectrum of interests. The primary entity that articulated a desired condition was the Resource Users Management Team (RUMT). It was composed of 35 individuals representing a wide array of Bay users and interest groups. Members were selected after an exhaustive series of interviews and were chosen because they met one or more of these criteria:

Serves as a spokesman for a major user or interest group.

Has experience in the development of water quality and resource management policy.

Is knowledgeable about the technical and economic feasibility of some of the pollution control options being considered by CBP.

Is potentially affected by the management recommendations of CBP.

In its final meeting in April 1983 in Fredericksburg, Virginia, RUMT recommended the goal of restoring Bay water quality to the conditions existing in 1980. The recommendations for biota were to restore lost fisheries and to maintain the existing ones. The Management Committee concurred with the stated RUMT goals. This statement of the problem, combined with clear, quantifiable goals and objectives, set the stage for the next step, which was the development of action tasks.

5.1.3 Specific Action Tasks

Specific tasks, which are the action items in the Management Report titled "Chesapeake Bay: A Framework of Action," have evolved from a series of sessions between EPA and the States. The report contains recommendations only; it is not a contract and does not represent agreement by the states to implement its recommendations.

The tasks in the Management Report are the result of a series of negotiating sessions. They are a compromise between the best judgment of what is needed to improve water quality in a particular watershed with what is politically acceptable in that watershed. Throughout the negotiating process it was pointed out repeatedly that the States have the primary responsibility to clean up their waters while EPA has an oversight role.

5.1.4 Accountability

Accountability in this context incorporates the concept of a public iterative process, combined with political oversight and combined federal/state management. The CBP has been since its beginning a highly visible program with its own public and, therefore, political constituency. While the high level of interest by the press and elected officials is not unique to the CBP, it has affected the development of CBP products including the Management Report.

The Bay is a national resource with a substantial following that is acutely aware of virtually every aspect of Bay management. There were at least three categories of CBP watchers: state and federal political agencies; Congress; and the private sector, which was represented by organizations such as the Chesapeake Bay Foundation (CBF) and the Citizens Program for the Chesapeake Bay. These forces provided a constant check on the CBP to insure that the interests of the broadest possible spectrum of Bay users were represented at all times.

5.2 INVOLVING BAY USERS

A very effective plan to involve the public at all steps was undertaken from the very beginning of the CBP. This report will focus briefly on the role of the following groups: Citizens Program for the Chesapeake Bay, Inc. (CPCB), RUMT, Citizens Steering Committee (CSC), the Water Quality Management Team, and the Urban Task Force.

5.2.1 Citizens Program for the Chesapeake Bay

The CPCB has been the primary umbrella organization that has coordinated the majority of the outreach programs for the CBP, including the RUMT and CSC. In addition to being a member of the Management Committee, the CPCB has been the focal point of public information and coordination. The CPCB has:

Initiated and coordinated a series of mini-conferences on Bay goals and objectives,

Published over 20 editions of the CPCB newsletter with a circulation of over 10,000 each,

Prepared newspaper supplements, one of which was circulated to over 200,000 Bay area residences,

Coordinated and participated in hundreds of television and press interviews,

Prepared a film titled "Chesapeake Bay Challenge" that was shown on all commercial television networks, and

Coordinated special forums for interested user groups.

5.2.2 Resource Users Management Team

In the spring of 1981 it became apparent that more specialized advice from the private sector was needed in order to develop the Management Report. Responding to this need, the Resource Users Management Team (RUMT) was established. RUMT has met officially five times since the fall of 1981. The last RUMT meeting in

Fredericksburg, Virginia, April 1983, produced a draft series of goals, objectives, and recommendations for the water quality and resources of the Bay. Those recommendations are summarized as follows:

Restore and maintain Bay water quality at 1980 levels.

Restore finfish and shellfish fisheries.

Impose a phosphorous limit of 1 milligram per liter for all point source discharges.

Set priorities for intensive funding for targeted nonpoint sources (NPS) of pollution.

Begin the implementation phase immediately.

Do not allow any further degradation of any section of the Bay.

Actively manage resources as well as water quality.

Identify and implement agricultural Best Management Practices (BMP) by region.

Fund the Mason-Dixon project.

Strengthen and implement 208 plans.

Conduct research on BMP's for NPS losses of nitrogen and nitrogen infiltration of groundwater.

Find solutions to NPS problems that do not put agriculture out of business.

Enforce the toxic chemical programs that are currently in effect including but not limited to NPDES, TOSCA, and RECRA.

Continue the Management Committee, a strong federal presence, public participation, and the RUMT.

5.2.3 Citizens Steering Committee

The Citizens Steering Committee was formed in 1978. It was composed of a cross section of representatives of public interest groups and private citizens who were community leaders and who were knowledgeable about public perceptions of Bay problems. The CSC met 28 times between 1978 and 1982 to comment on the direction and conduct of the CBP.

5.2.4 Water Quality Management Team (WQMT)

This group acted in an advisory capacity and commented in depth on the practicality and feasibility of the draft management recommendations. Since mid-level managers within state and local organizations would be tasked with carrying out recommendations of the CBP, they were asked to "join" the CBP. The WQMT consists of a group of managers involved with administering industrial permits, construction of new sewage treatment plants, nonpoint source control planning, and monitoring of watersheds. These professionals understood technical terms and were cognizant of existing regulations and their shortcomings.

5.2.5 Urban Task Force

This Task Force focused primarily on the role of local and regional governments in reducing urban runoff and planning stormwater/sewer duplex systems. Representatives on the Urban Task Force came from the Baltimore Regional Planning Council, Hampton Roads Water Quality Management Authority, and the Greater Washington Council of Governments.

5.3 DISSEMINATION OF CBP FINDINGS AND MANAGEMENT RECOMMENDATIONS

The process of dissemination of the findings and recommendations of the CBP was closely linked with the CPCB. The CPCB played a lead role in communicating all phases of the program to both the general public and to a wide range of users. An additional dissemination process is the scheduled Governor's Conference December 7-9 at George Mason University in Fairfax, Virginia.

The Governor's Conference titled, "Choices for the Chesapeake: An Action Agenda," is sponsored by The Honorable Harry R. Hughes, Governor of Maryland; The Honorable Charles S. Robb, Governor of Virginia; The Honorable Richard L. Thornburgh, Governor of Pennsylvania; The Honorable Marion S. Barry, Jr., Mayor of the District of Columbia; the Chesapeake Bay Commission; and the U. S. Environmental Protection Agency. The conference will be convened to "develop a strategy for regional management of Chesapeake Bay to assure protection and enhancement of the Bay's living resources." It is expected that the conference will in part use the recommendations of the CBP as the foundation for a compact between the governors and the public. The compact may include specific action steps to be taken by the conference participants to "assure protection and enhancement of the Bay's living resources."

5.4 LESSONS LEARNED

A discussion of the lessons learned will include both general observations that apply equally well to the entire effort and specific suggestions that apply only to the process of developing a plan to improve the Bay's environmental quality.

The general recommendations include the following:

> Plan for continuity between the research and implementation phases of a program. The transition will be infinitely simpler if one plans in advance to have some continuity of staff and an institutional memory. Experiences at the end of the CBP suggest that the planning and implementation phases would benefit from the expertise of a cadre of the core staff who were involved in research.
>
> Plan for even greater involvement in the implementation process by the states and agriculture and user communities. As the need for state and local programs grows, affected groups will become more involved in trying to influence actions. Federal managers should anticipate this shift in emphasis.

Specific recommendations include the following:

> Computerize to the greatest extent possible data on both point and nonpoint characteristics.
>
> Prepare for smaller and smaller geographical units of data. The next step after a basin profile with subbasin recommendations will be requests for action plans down to each STP, farm, or municipality.
>
> Determine in advance which variables will be needed by the next generation of mathematical modelers. This will avoid duplications if the variables are coordinated in advance and are compatible.
>
> Be certain to include all constituencies in the planning process--particularly at the state level.