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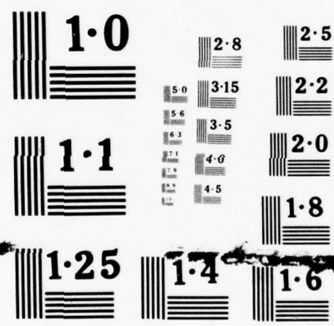
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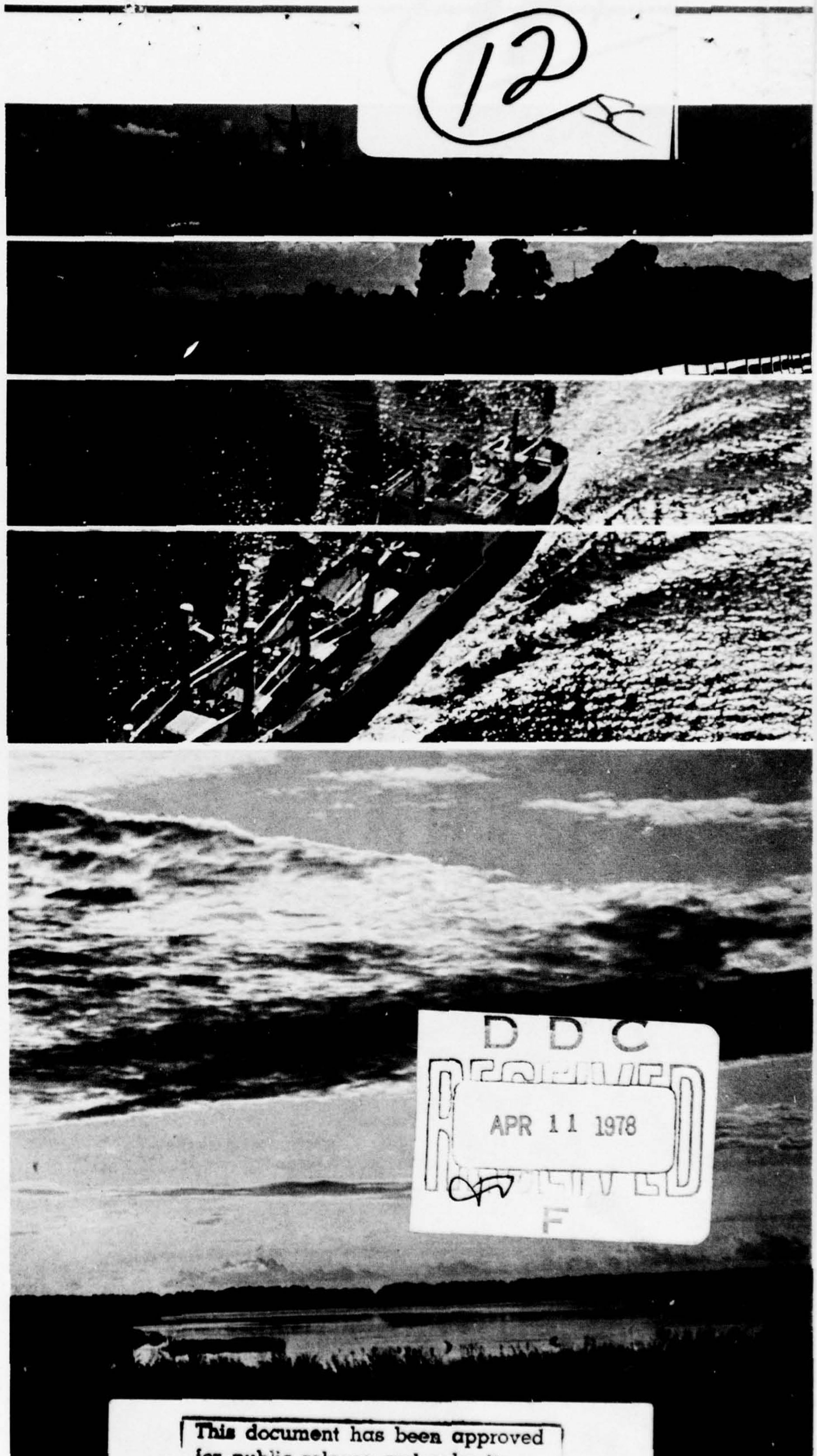

Chesapeake Bay
FUTURE CONDITIONS REPORT

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PREFACE

The Corps of Engineers' comprehensive study of Chesapeake Bay is being accomplished in three distinct developmental stages or phases. Each of these phases is responsive to one of the following stated objectives of the study program.

1. To assess the existing physical, chemical, biological, economic and environmental conditions of Chesapeake Bay and its related land resources.

2. To project the future water resources needs of Chesapeake Bay to the year 2020.

3. To formulate and recommend solutions to priority problems using the Chesapeake Bay Hydraulic Model.

In response to the first objective of the study, the initial or inventory phase of the program was completed in 1973 and the findings were published in a document titled Chesapeake Bay Existing Conditions Report. Included in this seven-volume report is a description of the existing physical, economic, social, biological and environmental conditions of Chesapeake Bay. This was the first published report that presented a comprehensive survey of the entire Bay Region and treated the Chesapeake Bay as a single entity. Most importantly, the report contains the historical records and basic data required to project the future demands on the Bay and to assess the ability of the resource to meet those demands.

In response to the second objective of the study, the findings of the second or future projections phase of the program are provided in this the Chesapeake Bay Future Conditions Report. The primary focus of this report is the projection of water resources needs to the year 2020 and the identification of the problems and conflicts which would result from the unrestrained growth and use of the Bay's resources. This report, therefore, provides the basic information necessary to proceed into the next or plan formulation phase of the program. It should be emphasized that, by design, this report addresses only the water resources related needs and problems. No attempt has been made to identify or analyze solutions to specific problems. Solutions to priority problems will be evaluated in the third phase of the program and the findings will be published in subsequent reports.

The Chesapeake Bay Future Conditions Report consists of a summary document and 16 supporting appendices. Appendices 1 and 2 are general background documents containing information describing the history and conduct of the study and the manner in which the study was coordinated with the various Federal and State agencies, scientific institutions and the public. Appendices 3 through 15 each contain information on specific water and related land resource uses to include an inventory of the present status and expected future needs and problems. Appendix 16 focuses on the formulation of the initial testing program for the Chesapeake Bay Hydraulic Model. Included in this appendix is a description of the hydraulic model, a list of problems considered for inclusion in the initial testing program and a detailed description of the selected first year model studies program.

The published volumes of the Chesapeake Bay Future Conditions Report include:

Volume Number	Appendix Number and Title
1	Summary Report
2	1 - Study Organization, Coordination and History
	2 - Public Participation and Information
3	3 - Economic and Social Profile
4	4 - Water-Related Land Resources
5	5 - Municipal and Industrial Water Supply
	6 - Agricultural Water Supply
6	7 - Water Quality
7	8 - Recreation
8	9 - Navigation
	10 - Flood Control
	11 - Shoreline Erosion
9	12 - Fish and Wildlife
10	13 - Power
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CHAPTER I

INTRODUCTION

The Chesapeake Bay Study developed through the need for a complete and comprehensive investigation of the use and control of the water and related land resources of Chesapeake Bay. In the first phase of the study, the existing physical, biological, economic, social and environmental conditions and the present problem areas in the Bay were identified and presented in the Chesapeake Bay Existing Conditions Report. The Future Conditions Report, of which this appendix is a part, presents the findings of the second or projections phase of the study. As part of this second phase of the study, projections of future needs and problem areas, means to satisfy those needs, and recommendations for future studies and hydraulic model testing were developed for each of the resource categories evaluated. The results of this phase of the study constitute the next step toward the goal of developing a comprehensive water resource management program for Chesapeake Bay.

The planning effort presented in this appendix deviates from the stated intent of the Future Conditions Report because it is oriented towards beginning the process of solving high priority problems rather than projecting future demands on the resource. This is accomplished by focusing on the formulation of a first year hydraulic studies program for the Chesapeake Bay Hydraulic Model. Included in this appendix is a description of the hydraulic model, a listing of the problems considered for inclusion in the first year of studies program, a priority ranking of the problems based on their economic, environmental and social impacts, and a description of the selected first year hydraulic studies program. Also included is a conceptual design of each candidate hydraulic study and a final design of the selected studies.

AUTHORITY

The authority for the Chesapeake Bay Study and the construction of the hydraulic model is contained in Section 312 of the River and Harbor Act of 1965, adopted 27 October 1965, which reads as follows:

> (a) The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to make a complete investigation and study of water utilization and control of the Chesapeake Bay Basin, including the waters of the Baltimore Harbor and including, but not limited to, the following: navigation, fisheries, flood control, control of noxious weeds, water pollution, water quality control, beach erosion, and recreation. In order to carry out the purposes of this section, the Secretary, acting through the Chief of Engineers, shall contruct, operate, and maintain in the State of Maryland a hydraulic model of the Chesapeake Bay Basin and associated technical center. Such model and center may be utilized, subject to such terms and conditions as the Secretary deems necessary, by any department, agency, or instrumentality of the Federal Government or of the States of Maryland, Virginia, and Pennsylvania, in connection with any research, investigation, or study being carried on by them of any aspect of the Chespeake Bay Basin. The study authorized by this section shall be given priority.
>
> (b) There is authorized to be appropriated not to exceed $6,000,000 to carry out this section.

An additional appropriation for the study was provided in Section 3 of the River Basin Monetary Authorization Act of 1970, adopted 19 June 1970, which reads as follows:

> In addition to the previous authorization, the completion of the Chesapeake Bay Basin Comprehensive Study, Maryland, Virginia, and Pennsylvania, authorized by the River and Harbor Act of 1965 is hereby authorized at an estimated cost of $9,000,000.

As a result of Tropical Storm Agnes, which caused extensive damage in Chesapeake Bay, Public Law 92-607, the Supplemental Appropriation Act of 1973, signed by the President on 31 October 1972, included $275,000 for additional studies of the impact of the storm on Chesapeake Bay.

PURPOSE

FUTURE CONDITIONS REPORT

Previously, measures taken to utilize and control the water and land related resources of the Chesapeake Bay Basin have generally been directed toward the solution of individual problems. The Chesapeake Bay Study provides a comprehensive study of the entire Bay Area in order that the most beneficial use be made of the water-related resources. The major objectives of the Study are to:

a. Assess the existing physical, chemical, biological, economic and environmental conditions of Chesapeake Bay and its water resources.

b. Project the future water resources needs of Chesapeake Bay to the year 2020.

c. Formulate and recommend solutions to priority estuarine problems using the Chesaeake Bay Hydraulic Model.

The Chesapeake Bay Existing Conditions Report, published in 1973, met the first objective of the study by presenting a detailed inventory of the Chesapeake Bay and its water resources. Divided into a summary and four supporting appendixes, the report presented an overview of the Bay area and the economy; a survey of the Bay's land resource and its use; and a description of the Bay's life forms and hydrodynamics.

The purpose of the Future Conditions Report is to provide a format for presenting the findings of the Chesapeake Bay Study. Satisfying the second objective of the Study, the report describes the present use of the resource, presents the demands to be placed on the resource to the year 2020, assesses the ability of the resource to meet future demands, and identifies additional studies to develop a management plan for Chesapeake Bay.

REPORT ON THE FIRST YEAR HYDRAULIC STUDIES PROGRAM

Estuaries, such as Chesapeake Bay, are very complex water bodies which are subject to hydrologic, meteorologic and astronomic forces, some as yet not completely defined. Because of this, solutions to many types of estuarine-related problems are not possible unless sophisticated analytical techniques and tools are available. Such a tool is the hydraulic model of Chesapeake Bay. This model will provide to the scientific and engineering community an accurate reproduction of the Bay and its physical processes--a reproduction that will allow the simulation of many natural events and man-made changes and from which can be obtained not only the data necessary to assess the environmental consequences of these happenings, but the information necessary to allow man to use the Bay in such a manner so as to preserve and enhance it. If this is to be accomplished, it is important that, from the very beginning of the hydraulic model study program, maximum economic use be made of this tool. It is therefore the primary purpose of the planning effort presented in this appendix to formulate a comprehensive and economic program of studies to be accomplished during the first year of operation of the hydraulic model of Chesapeake Bay.

SCOPE

FUTURE CONDITIONS REPORT

The scope of the Chesapeake Bay Study and Future Conditions Report includes the multi-disciplinary fields of engineering and the social, physical, and biological sciences. The study is being coordinated with all Federal, State, and local agencies having an interest in Chesapeake Bay. Studied subregionally, each resource category presented in the Future Conditions Report projects demands and potential problem areas to the year 2020. All conclusions are based on historical information supplied by the preparing agencies having expertise in that field. In addition, the basic assumptions and methodologies are quantified for accuracy in the sensitivity section. Only general means to satisfy the projected resource needs are presented, as recommendations for specific areas are beyond the scope of the Study.

REPORT ON THE FIRST YEAR HYDRAULIC STUDIES PROGRAM

The first year program of studies on the Chesapeake Bay Hydraulic Model is formulated solely within the context of available fiscal and temporal resources. As such, it reflects the fact that at the time formulation was accomplished, sufficient funds had been authorized for only one year's operation of the model, although it is hopefully anticipated that studies will continue for many additional years. Because of these restraints, only the more apparent, pressing problems were included in the analysis--problems which were identified in the Existing Conditions Report and by government officials and other concerned citizens who contributed so much to the study. It was not possible, however, to take advantage of the vast array of information contained in the Future Conditions Report as work on this report had not been completed at the time the first year study program was formulated. It is therefore important to recognize that all information contained in this document such as the list of problems, problem impact analyses, and problem priorities are all in the context of one year of studies on the hydraulic model of Chesapeake Bay although later studies have shown that the first year tests would probably have been selected under any circumstances.

SUPPORTING STUDIES

This appendix was coordinated and prepared by the Baltimore District, Corps of Engineers. The data base for this particular volume, as well as all other volumes of this report, was presented in the Chesapeake Bay Existing Conditions Report.

STUDY PARTICIPANTS AND COORDINATION

The magnitude of this study, the large number of participants, and the complex spectrum of problems requires a high degree of coordination of the various study activities. This Study was conceived and has developed as a coordinated partnership between Federal, State and interested educational institutions. As explained in Appendix 1 of this report, an Advisory Group, a Steering Committee and five Task Groups were formed to coordinate and review the study effort. This appendix was prepared by the Corps of Engineers under the guidance of and with the review of the Advisory Group and Steering Committee. The first year's hydraulic model program presented in this document was fully concurred in by both groups during a joint meeting held on 28 May 1975.

CHAPTER II

THE CHESAPEAKE BAY HYDRAULIC MODEL

INTRODUCTION

The hydraulic model is one of the most versatile instruments available to the hydraulic engineer, water resources planner and scientist. In the Chesapeake Bay Study, the hydraulic model provides a means of reproducing to a manageable scale many natural events and man-made changes and thereby allows the collection of the data necessary to assess the consequences of these happenings. As an instrument and physical display, the hydraulic model is unexcelled in its potential for the education of an interested public in the scope and magnitude of the problems and conflicts of use that can beset this water resource. And, as an operational focal point, it can promote more effective liaison among the agencies working in the Bay waters, helping to reduce duplication of effort and leading to the accelerated spreading of knowledge among the interested parties of the public.

The hydraulic model of Chesapeake Bay is a facility of the Baltimore District, Corps of Engineers, and all aspects of the model-related program are the responsibility of the Baltimore District Engineer. The personnel of the Waterways Experiment Station, however, are the Corps of Engineers recognized experts in hydraulic modeling. In view of this, the District Engineer has entered into a memorandum of understanding with the Director of the Waterways Experiment Station under which the Director has agreed to design, construct, and operate and maintain the Chesapeake Bay Hydraulic Model.

LOCATION

The hydraulic model of Chesapeake Bay is located at Matapeake, Maryland, on a 65 acre tract of land donated by the State of Maryland. The site is on the Delmarva Peninsula, lies along Maryland Route 8, and is approximately 3 miles south of the eastern terminus of the William Preston Lane Memorial Bridge (Chesapeake Bay Bridge). It is within commuting distance of over 3,000,000 people being less than 50 miles from both Washington, D.C. and Baltimore, Maryland.

DESCRIPTION

The hydraulic model of Chesapeake Bay is the largest estuarine model in the world. It is a fixed bed geometrically distorted scale model hand molded in concrete; is 9 acres in area; and encompasses the Bay proper, all of its tributaries up to the head of tidal effects, and the adjacent overbank areas to the contour of 20 feet above mean sea level. The model is enclosed in a 14 acre prefabricated steel truss building in order to protect it from such elements as wind, rain, and debris. Figures 16-1 to 16-3 are pictures of the model shelter, the model itself, and a map showing the model limits.

Chesapeake Bay conforms to the typical form of coastal plain estuaries, which are generally broad shallow water bodies. The average depth lies between 25 and 28 feet; and if the model were to be constructed to a reasonable natural scale, water depths would be generally extremely shallow. Because of this, the water would be too shallow to make meaningful measurements, and the effects of water surface tension would disturb model results.

To overcome these problems, the Chesapeake Bay Model, like almost all estuary models is geometrically distorted. This means that it is constructed disproportionately by using larger scales for vertical dimensions than for horizontal dimensions. The degree of distortion, as well as the actual scales selected,

Figure 16-1: Chesapeake Bay Hydraulic Model Shelter

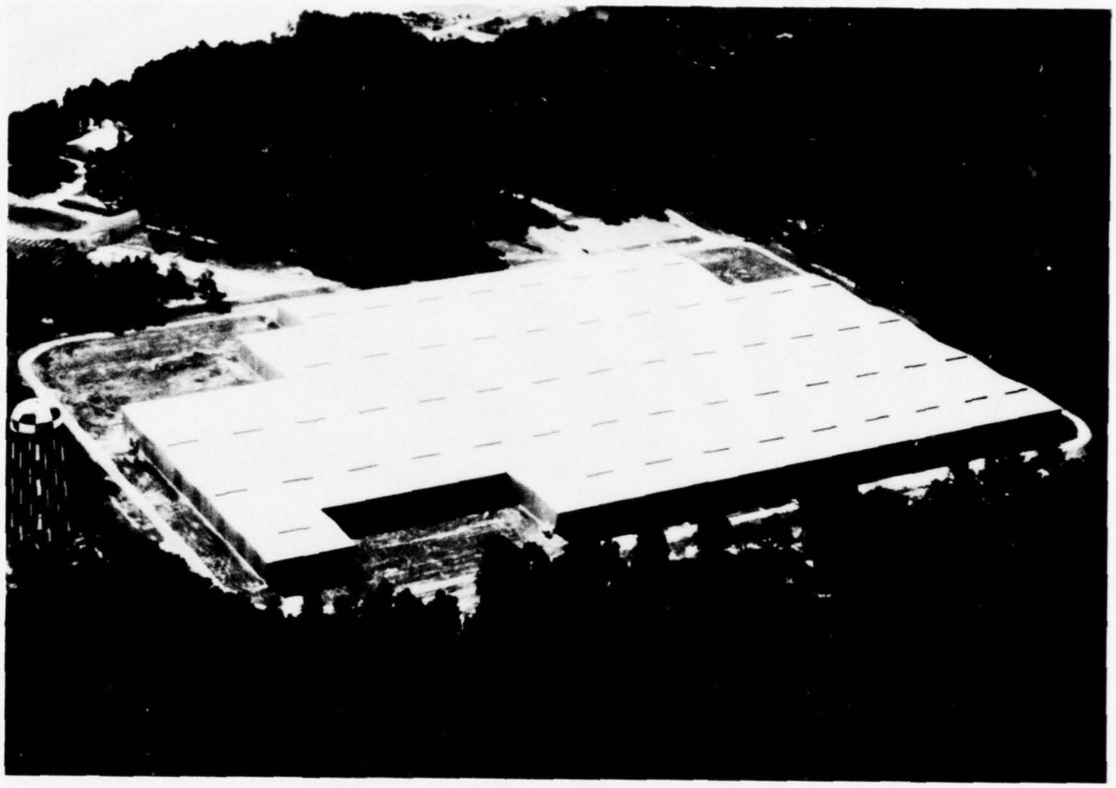

Figure 16-2: Chesapeake Bay Hydraulic Model

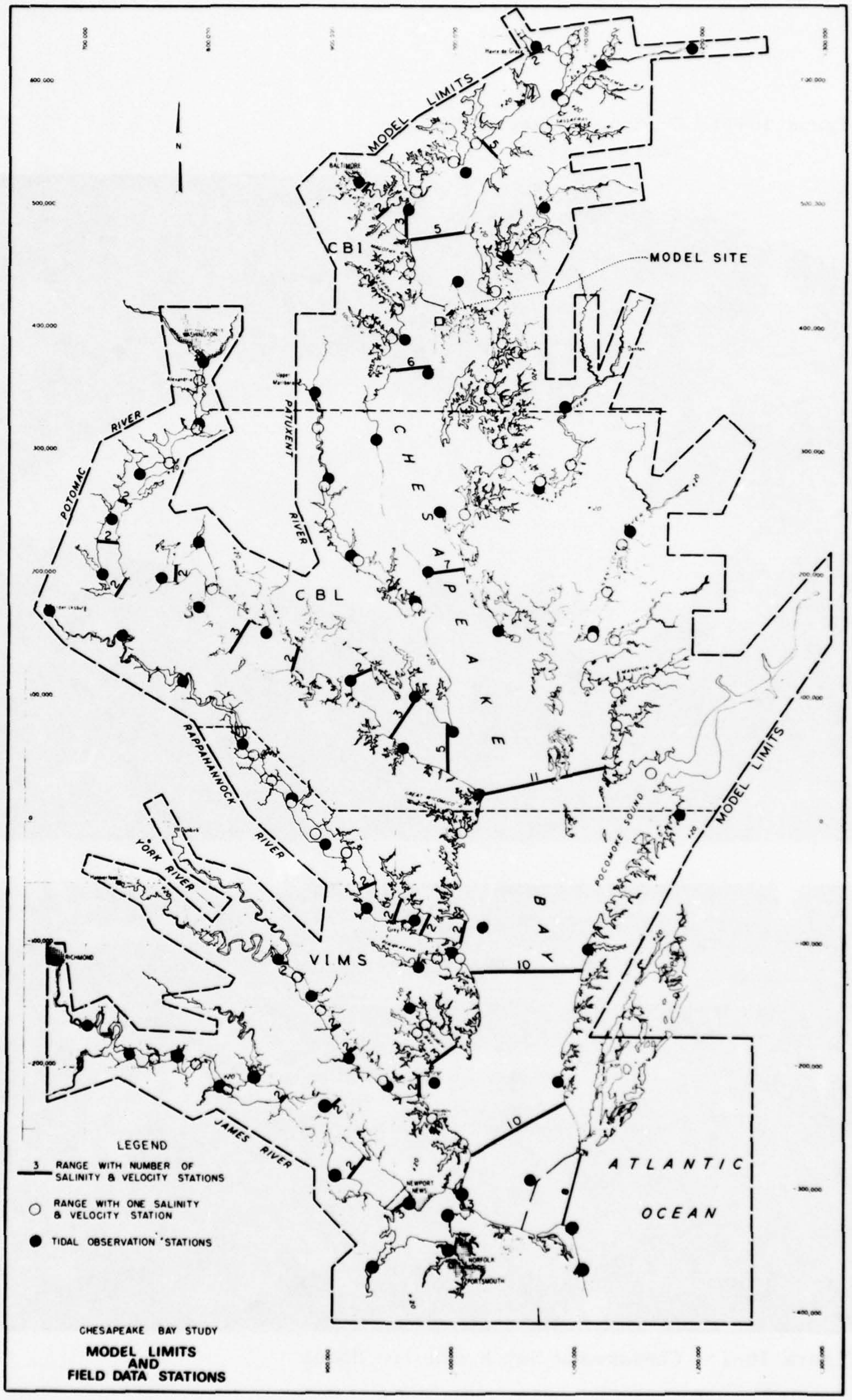

Figure 16-3: Model Limits and Field Data Stations

is dependent on many factors including the size of the area that must be reproduced and the problems to be investigated. The Chesapeake Bay Model is, therefore, constructed with scales of 1 to 1,000 horizontally and 1 to 100 vertically. This combination of scales is referred to as a distortion ratio of 10. This particular scale ratio has been found, over many years of experience, to provide the most economically sized model that will accurately reproduce the vertical and lateral distributions of current velocity, salinity, and tidal elevation.

The model's geometric scales also determine the time, volumetric, and velocity scales. The time scale is 1 to 100 which permits a semi-diurnal tidal cycle of 12 hours and 25 minutes to be reproduced in 7.45 minutes and a year of record in nature to be simulated in 3.65 days. The velocity scale is 1 to 10, the discharge scale 1 to 1,000,000 and the salinity scale is 1 to 1.

The total wetted area of the model at mean low water is almost 166,000 square feet and at mean high water about 184,000 square feet. The volume of water needed to fill the model to mean low water is about 450,000 gallons, and the amount of additional water required for the spring tide is about 36,000 gallons.

CAPABILITIES

There are six basic measurements that are made on estuarine hydraulic models. These include water surface elevation, salinity, current velocity, dye concentration from dye dispersion tests, temperature, and sediment distribution. These measurements can effectively describe the physical impact on an estuarine resource of many of the works of man. Often, biological stress can be predicted from the knowledge of changing physical parameters.

The anticipated capability of the Chesapeake Bay Model to reproduce physical prototype data is as follows:

a. Water surface elevation can be measured to 0.001 foot in the model, representing 0.1 foot in the prototype.

b. Current velocity can be measured within ± 0.02 foot per second. This would represent 0.2 foot per second in the prototype. Verification procedures indicate that model velocities may vary up to 20 percent from that in the prototype.

c. Salinity can be measured in the model to the same accuracy as in the prototype. Model and prototype salinity are in a 1:1 relationship.

d. Dye concentration, from dye dispersion tests, can be measured by fluorometric methods to 1.0 ppb. The model can be used to predict the distribution and concentration of conservative water quality constituents to an accuracy of about 20 percent.

e. Temperature can be measured to an accuracy of about plus or minus 0.1 degrees Celsius.

f. For sediment distribution studies, the volume distribution of Gilsonite, or other material simulating sediment, over a specified unit area is a standard measure. This is considered to be qualitative procedure.

PROTOTYPE DATA

Once construction of a model is completed, its operating similarity to an estuary's hydraulic and salinity phenomena must be verified. In order to accomplish this for the Chesapeake Bay Model, an extensive prototype data collection program was initiated. This involved the collection of data concerning tidal elevations, current velocities, and salinities at various points throughout the Bay system. Tidal elevation data were collected at 72 locations, for at least one year's duration, by the National Ocean Survey, which also conducted a 1,000 mile first order survey to establish a common reference datum for the tidal stations. Current velocity and salinity data were acquired at over 700 different stations for periods ranging from 3 to 5 days. This work was accomplished under contract with the Johns Hopkins University, the University of Maryland, and the Virginia Institute of Marine Science. Figure 16-3 also shows the locations where prototype data were collected.

CHAPTER III

ESTABLISHING HYDRAULIC STUDY PRIORITIES

PROBLEMS

There are many problems in the Chesapeake Bay system of varying degrees of interest and concern, to which the hydraulic model may lend help in providing solutions. Very broadly, study problems canbe assigned to one of the following six technical problem study areas:

a. General Tests
b. Municipal and Industrial Water Supply
c. Wastewater Disposal
d. Power Plant Cooling Water and Thermal Additions
e. Navigation
f. Tidal and Fluvial Flooding

Within the context of the above general categories of problem areas, the specific list of studies shown on Column 1, Table 16-1 was developed. This listing contains a relatively large number of studies which are, for the most part, descriptive rather than oriented towards project specific hydraulic solutions.

Attachment A contains conceptual descriptions of all the individual tests considered for inclusion in the first year of hydraulic model studies. Included in the description of each individual test is its title, the objective of the test, tributary freshwater inflow conditions, tidal conditions, and estimates of the cost and time required to perform each study. The estimates of model time to do each study include only the performance of each individual test on the model. The time estimate does not include the time required to complete data analysis and report writing. The cost estimates shown for each individual test are at a January 1975 price level and include labor costs, the cost of data analysis and report writing, and the cost of salt consumed during the tests. Costs associated with the maintenance of the shelter and utilities are not included.

Although there are certainly other environmental concerns and other possible testing programs, the problems and tests described in Attachment A and shown in Column 1 of Table 16-1 were selected for study partially as a result of inquiry to various interested public agencies, interest or concern expressed by knowledgeable individuals, and as a result of information developed during the preparation of the Existing and Future Conditions Reports of the Chesapeake Bay Study.

IMPACT AND PRIORITY ANALYSIS

It is obvious that the large number of studies listed in Column 1 of Table 16-1 cannot be accomplished during the 1 year available to the Chesapeake Bay Study Program for hydraulic model studies. It then becomes of immediate importance to assign a priority to each individual study program to insure that the year available is used in a most productive and economic manner.

In this chapter the probable environmental, social, and economic impacts of the various problems listed in Column 1 of Table 16-1 are evaluated, and a preliminary priority rating for the accomplishment of each study is established.

However, in the next chapter each study will be further examined in relation to other important criteria necessary to be considered in the overall formulation of the first year hydraulic study program. These further criteria are:

1. The development of a sequence of tests conforming with the funding and time limitations of the presently authorized study, and which will in turn result in an efficient and economical schedule of model operations.

2. The probability of testing results being useful for not only presently stated purposes, but for both future planning studies and the analysis of ancillary problems related to an ongoing Chesapeake Bay Study.

3. The general usefulness of a particular hydraulic study series in demonstrating the versatility of the hydraulic model in providing useful data for problem solving.

Each problem impact category (i.e., environmental, social, and economic) is rated by estimating both its magnitude and severity as will be noted in Columns 2 through 7 on Table 16-1. The magnitude of an environmental impact is based on the area of the Chesapeake Bay system affected.

Social and economic impact magnitude is expressed in terms of the number of people affected. Problem severity for each problem impact category is expressed as an estimate of the intensity of the insult. The numerical index value of problem magnitude and severity for each impact category (environmental, social, and economic) is based on an ascending scale of 1 to 5. The number 1 indicates a mild impact--the number 5 indicates a most severe impact.

The criteria used to develop the index values for the magnitude of the environmental, social, and economic impacts for this analysis are shown below:

PROBLEM MAGNITUDE INDEX

Index Value	Magnitude	
1	Area:	Less than 5% total water area of the Chesapeake Bay system
	Population:	Cities less than 100,000 population County or groups of counties less than 150,000
2	Area:	5% to 15% total water area
	Population:	Cities 100,000-500,000 population Small groups of rural counties (e.g., Southern Maryland)

PROBLEM MAGNITUDE INDEX (Cont'd)

Index Value		Magnitude
3	Area:	15% to 25% total water area
	Population:	Cities 500,000 to 1,000,000 Moderate size group of counties (i.e., Northern Neck of Virginia)
4	Area:	30% to 50% total water area
	Population:	City larger than 1,000,000 Large group of rural counties
5	Area:	Greater than 50% total water area
	Population:	Several large metropolitan areas

Problem magnitude indices are relatively simplistic reflecting the population and water area impacted by various problems. These indices can be applied to any of the three problem impact categories (environmental, social, and economic) quite readily. On the other hand, development of indices reflecting problem severity is a much more involved process, in that many more parameters must be considered.

SEVERITY OF ENVIRONMENTAL IMPACT

The important factors to be considered in generating indices expressing the severity of environmental problems relate to disruption of ecologically important areas or species (wetlands, spawning areas, waterfowl habitat, oyster beds, fish of both sport and commercial value). These disruptions, though they can occur naturally, (floods, erosion problems, etc.) are primarily a function of the works of man, (waste water dispersion, heated discharges, increasing nutrient levels, upstream water diversions).

The criteria used for developing indices of the severity of environmental impact follow:

ENVIRONMENTAL IMPACT SEVERITY INDEX

Index Value	Problem Severity
1	Minimal temporary disruption of a few species or areas. No irreversible losses.
2	Significant temporary disruption of a few species or areas. No irreversible losses.
3	Permanent destruction of a few important species or areas. The overall ecosystem of the area, though permanently altered, will retain most of its original basic characteristics.
4	Permanent destruction of several important species or areas. The overall ecosystem of the area as well as some of its basic characteristics will be altered.
5	Permanent disruption of the entire ecosystem or resource area beyond any recovery.

When applying the above indices there is uncertainty concerning the potential severity of the environmental impacts. A conservative approach that takes into consideration the long-term integrity of the environment was followed.

SEVERITY OF SOCIAL IMPACT

There are many factors to be considered in deriving severity indices describing the social impact of problems. Among these are threats to public health and safety from severe bacteriological and chemical water pollution, dislocations of people or industries because of water quality or erosion/sedimentation and flooding problems, destruction of aesthetic or recreational areas, and limiting fields of personal development, to name a few. The criteria establishing the social severity index value follows:

SOCIAL IMPACT SEVERITY INDEX

Index Value	Problem Severity
1	Minimal loss of recreational opportunities. All types of recreation still available with some curtailment, minor reversible aesthetic degradation, no threat to public health or possibility of population dislocation.
2	Significant curtailment of recreational opportunity. Significant aesthetic degradation. No threat to public health or possibility of population dislocation.
3	Total loss of several important recreational opportunities, curtailment of others. Considerable aesthetic degradation. Minor threat to public health. Some minor population dislocation.
4	Total loss of many recreational opportunities, curtailment of others. Severe aesthetic degradation. Major population dislocation due, for example, to extensive flooding. Significant threat to public health.

SOCIAL IMPACT SEVERITY INDEX (Cont'd)

Index Value	Problem Severity
5	Total loss of water-related recreational opportunity. Severe threat to public health. Major population dislocations due to major flooding, erosion, etc.

SEVERITY OF ECONOMIC IMPACT

The important factors to be considered in assessing the degree of economic impact consist of the impact on employment and income, the impact on the competitive advantage of the area with respect to suitability for new or existing industrial location (for instance, water transportation cost in an area may increase because of siltation problems; this would decrease an area's competitive advantage for industries which rely on raw materials shipped by water), effect on water treatment cost for municipalities and industries, damages or losses of property due to flooding or erosion problems. These considerations have been interpreted into indices for measuring the economic impact of the various problems as follows:

ECONOMIC IMPACT SEVERITY INDEX

Index Value	Problem Severity
1	Minimal effects on employment and incomes, some impact on water treatment cost, minor losses or damages to property due to occasional minor flooding or low rates of erosion, insignificant losses in competitive advantage or efficiency, but not enough to affect the decision of a company not to locate, close down, or expand.

ECONOMIC IMPACT SEVERITY INDEX (Cont'd)

Index Value	Problem Severity
2	Minor effects on employment and incomes, significant impact on water treatment cost, minor losses or damages to property due to frequent minor flooding or moderate rates of erosion, significant losses in competitive advantage or efficiency, but not enough to affect the decision of a company not to locate, close down, or expand.
3	Significant effects on employment and incomes, major increases in water treatment cost, significant damages and losses in property due to frequent minor flooding or occasional to moderate heavy floods, or moderate rates of erosion, sufficient losses in efficiency and competitive advantage to cause some firms which would have located in the area in the absence of the problem not to locate there, or cause some existing firms to cut back production or close down.
4	Severe impact on employment and incomes, significant losses or damages to property due to frequent minor flooding or moderate rates of erosion, significant loss in efficiency and competitive advantage to cause many firms which would have located in the area in the absence of the problem not to locate there, or cause many existing firms to cut back production or close down.
5	Severe impact on employment and incomes, heavy losses or damages to property due to frequent heavy floods or very high rates of erosion, severe losses in competitive advantage sufficient to prevent most water-dependent firms from locating in that area, and causing most existing firms to close down.

Each problem area listed in Column 1 on Table 16-1 was reviewed individually on an environmental, social, and economic basis using readily available information. As a result, numerical indices expressing problem severity and magnitude were developed and assigned to each problem. In most cases there was sufficient information available to make a reasonable estimate of the index number value. The value of the various indices are shown in Columns 2 through 7 on Table 16-1.

Column 8, Table 16-1, contains the score for each problem area. This number is simply the sum of the various indices across the individual rows. As is indicated on Table 16-1, the lowest priority score is 10 and the highest is 21. The 12-point range was arbitrarily divided into three subranges.

Low Priority	-	10-13
Medium Priority	-	14-17
High Priority	-	18-21

Table 16-2 lists the problems in order of priority range. Columns 4 and 5 on this table contain estimates of time and cost to do each individual study. The additional time required for data analysis and report writing is not included in the time estimates. However, cost estimates do include appropriate allowances for the above activity.

At this point it may be well to discuss the significance of the priority index numbers derived in the preceding analysis. Though the establishment of the problem severity and magnitude indices are, in some cases, intuitive there are as many elements of hard fact in their estimation as it was possible to ascertain. Standing by themselves, however, the indices of problem magnitude and severity are all but meaningless. Meaning can be ascribed only through comparison between individual or combinations of individual indices.

TABLE 16-1
PROBLEM IMPACT INDICES

Technical Problem Areas	Environmental Impact Indices		Social Impact Indices		Economic Impact Indices		Indices
	Severity	Magnitude	Severity	Magnitude	Severity	Magnitude	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Bay-Wide General Tests							
1. Low Freshwater Inflow Study	3	5	3	4	2	4	21
2. High Freshwater Inflow Study	2	5	3	4	2	4	20
3. Tidal Flooding Study	2	5	3	4	3	4	21
B. Municipal Water Supply							
1. Potomac River Estuary Water Supply Study	2	2	4	4	2	2	18
2. Baltimore-Susquehanna River Water Supply Diversion	1	3	1	4	1	4	14
C. Power Plant Thermal Discharge Studies							
1. Proposed Upper Bay Power Plant Thermal Effects Study	3	1	2	5	2	5	18
2. Cumulative Lower Bay Power Plant Thermal Effects Study	3	1	2	5	2	5	18

TABLE 16-1 (cont'd)
PROBLEM IMPACT INDICES

Technical Problem Areas	Environmental Impact Indices		Social Impact Indices		Economic Impact Indices		Indices
	Severity	Magnitude	Severity	Magnitude	Severity	Magnitude	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C. **Power Plant Thermal Discharge Studies** (Continued)							
3. Cumulative Upper Bay Thermal Effects Study	3	3	2	5	2	5	20
D. **Navigation Studies**							
1. Baltimore Harbor Channel Enlargement Study	3	3	3	4	4	4	21
2. North Bay Dredged Material Disposal Study	5	1	3	4	4	4	21
3. Norfolk Harbor Channel Enlargement Study	3	2	3	3	4	3	18
4. South Bay Dredged Material Disposal Study	4	1	3	3	4	3	18
5. York River Channel Enlargement Study	3	1	3	1	3	1	12

TABLE 16-1 (cont'd)
PROBLEM IMPACT INDICES

Technical Problem Areas	Environmental Impact Indices		Social Impact Indices		Economic Impact Indices		Indices
	Severity	Magnitude	Severity	Magnitude	Severity	Magnitude	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
E. **Waste Water**							
1. Potomac River Estuary Waste Water Dispersion Study	3	2	3	4	1	4	17
2. Patuxent River Estuary Waste Water Dispersion Study	3	1	3	2	1	2	12
3. James and Elizabeth Rivers Estuaries Waste Water Dispersion Study	3	2	3	4	1	4	17
4. Patapsco River Waste Water Dispersion Study	3	2	3	4	1	4	17
5. Back River Waste Water Dispersion Study	3	1	2	4	1	2	13

TABLE 16-2
PRIORITY RANKING OF INDIVIDUAL STUDIES

Priority Range (1)	Indice Total Score (2)	Technical Problem (3)	Time Weeks (4)	Cost* Dollars (5)
High Priority 18-21	21	A1 - Low Freshwater Inflow Study	23	$410,000
	21	A3 - Tidal Flooding Study	14	510,000
	21	D1 - Baltimore Harbor Channel Enlargement Study	16	230,000
	21	D2 - North Bay Dredged Material Disposal Study	16	230,000
	20	A2 - High Freshwater Inflow Study	9	170,000
	20	C3 - Cumulative Upper Bay Thermal Effects Study	7	105,000
	18	B1 - Potomac River Estuary Water Supply Study	6	105,000
	18	C1 - Proposed Upper Bay Power Plant Thermal Effects Study	5	80,000
	18	C2 - Cumulative Lower Bay Power Plant Thermal Effects Study	9	140,000
	18	D3 - Norfolk Harbor Channel Enlargement Study	10	155,000
	18	D4 - South Bay Dredged Material Disposal Study	18	250,000

TABLE 16-2 (cont'd)
PRIORITY RANKING OF INDIVIDUAL STUDIES

Priority Range (1)	Indice Total Score (2)	Technical Problem (3)	Time Weeks (4)	Cost* Dollars (5)
Medium Priority 14-17	14	B2 - Baltimore-Susquehanna River Water Supply Diversion	6	$ 95,000
	17	E1 - Potomac River Estuary Waste Water Dispersion Study	5	85,000
	17	E3 - James and Elizabeth Estuaries Waste Water Dispersion Study	7	105,000
	17	E4 - Patapsco River Estuary Waste Water Dispersion Study	5	80,000
Low Priority 10-13	12	D5 - York River Channel Enlargement Study	8	115,000
	12	E2 - Patuxent River Estuary Waste Water Dispersion Study	5	80,000
	13	E5 - Back River Estuary Waste Water Dispersion Study	5	80,000

*Does not include costs of shelter operation and maintenance.

CHAPTER IV

FORMULATION OF THE PROPOSED TESTING PROGRAM

THE FORMULATION PROCESS

Formulation of the first year program of studies on the hydraulic model of Chesapeake Bay was an iterative process. Based on the input of the members of both the Advisory Group and Steering Committee, the staff of the Corps of Engineers prepared a preliminary draft of this document and submitted it to the members of both committees. In the preliminary draft, conceptual designs of each potential model study were presented, rationale for program selection was developed, and a tentative first year study program was selected. During a joint meeting of the Advisory Group and Steering Committee the preliminary draft document was reviewed and certain changes in both the test designs and the selected program were adopted. Subsequent to the meeting, the draft report was reviewed to reflect the final formulation process and a detailed design of the studies selected for inclusion in the first year program was developed in a joint effort between members of the Steering Committee and the Corps staff. These detailed designs are shown in Attachment B.

CRITERIA

It was not the purpose of the problem impact analysis to develop a decision-making device for formulating the hydraulic study program, rather the purpose was to provide an input to the decision-making process. It should be obvious that this system is neither so definitive nor is it so comprehensive as to be sensitive enough for sole decision input for developing an economical and efficient testing program. As mentioned earlier, there are many other factors as well as study priority that strongly influence the development of the hydraulic study program. At this point these factors bear repitition, and even some elaboration, as follows:

a. The importance of the particular study to the Corps' Chesapeake Bay Study.

b. The formulation of a hydraulic study program that can be completed within the funding and time constraints of the presently authorized Chesapeake Bay Study, and that most economically utilizes the available resource, e.g., labor, instrumentation, etc.

c. Hydraulic studies that are not only presently necessary but may be of use in the future.

d. Hydraulic studies that demonstrate the utility and versatility of the hydraulic model.

e. The demand for a particular study by other public agencies or interested groups.

FORMULATION

The list of high priority studies was then examined in the light of the foregoing criteria for the purpose of selecting those study problems that should be accomplished during the first year of model testing operations.

It was found that although the Tidal Flooding Study was one of top priority and would be of value to the Chesapeake Bay Study in identifying flood prone areas, there were a few factors that make its selection as a first year study subject questionable. First and foremost, this study would require the purchase of an estimated $180,000 in extra instrumentation for automatically measuring and recording water surface elevation in the hydraulic model. At the same time, this study would require considerable added complex mathematical modeling for its implementation. The mathematical analysis would isolate the effects of wind "setup" on the water surface elevation at various points in Chesapeake Bay. The wind setup effects would then be compared with model recorded storm surge elevations and the astronomical tide to determine the elevation of tidally induced flooding. This analytical work is estimated to cost at least $100,000. Since an estimated $280,000 would be required for extra instrumentation and analytical work, the most economical use of the model would not be made, as the money spent for this would result in a shortened program. In addition, there did not appear to be as much support for this study by public agencies or interested groups as there was for some of the other studies.

The Low and High Freshwater Inflow Studies are significant in that, as Bay-wide studies, they can provide reconnaissance scope data that would illustrate the function of Chesapeake Bay under various freshwater inflow conditions. Both of these studies are particularly important to the Chesapeake Bay Study and indeed the well-being of society, as they would define the translation of the salinity regime and the changes in estuarine flushing patterns that would occur during periods of adverse hydrologic conditions. These parameters have widespread ecological ramifications--salinity changes affecting the environment under which aquatic species live and spawn, and flushing characteristics impacting on wastewater dispersion and time distribution of nutrients and sediments. Studies of these types are of immediate importance and would provide information that is vital in decision-making in the foreseeable future. In addition, both of these studies represent tests that are particularly appropriate for the application of hydraulic modeling techniques and would effectively demonstrate the versatility and utility of the hydraulic model of Chesapeake Bay.

Either the high flow or low flow test can be completed within available fiscal and temporal resources although neither one of them is inexpensive. Each represents a most effective economic use of available resources as the benefits to be derived far outweigh the costs. Also these studies would be useful in the design of more detailed experiments oriented toward further describing the effects of modified inflow conditions.

The need for a low flow type study has been recognized for many years and was emphatically recommended by the Susquehanna River Basin Coordinating Committee in its 1970 report on the Susquehanna River Basin. The State of Maryland, the Commonwealth of Virginia, and the Susquehanna River Basin Commission have also expressed concern over the effects of a possible depletion of freshwater inflows by upstream diversions and consumptive losses. In addition, it was the unanimous consensus of the members of both the Advisory Group and Steering Committee that freshwater inflows to Chesapeake Bay during drought periods are one of the most important factors in maintaining a healthy biotic community and if at all possible, should be addressd during the first year of testing on the hydraulic model of Chesapeake Bay.

The high flow study, however, is not quite so widely supported as a candidate for the first year testing program. Although the ecological and economic impacts of extremely high freshwater inflows such as those which occurred during Tropical Storm Agnes are rather severe and not completely understood, unlike low flows, high freshwater inflows have occurred recently and through a quirk of fate were rather well monitored. At the time Agnes occurred, the Chesapeake Bay Biological Laboratory of the University of Maryland and the Virginia Institute of Marine Science were mobilized to collect prototype data for the Corps of Engineers' Chesapeake Bay hydraulic model. They responded immediately to the crisis created by the storm by diverting their forces to the collection of data relevant to Agnes. Although it was fully recognized that it was not possible to collect all of the data needed to make intelligent long range decisions and that a model study of the effects of high freshwater inflows must eventually be accomplished, the Advisory Group, Steering Committee, and other concerned persons indicated their belief that the high freshwater inflow test did not represent the best use of the limited first year fiscal and temporal resources.

The Baltimore and Norfolk Harbor Channel Studies are important high priority regional tests designed to assess the environmental impact of deepening the channels leading to these ports. Of immediate concern are the potential changes to the hydraulic regime of Chesapeake Bay which may occur as a result of this deepening--particularly those factors related to tidal elevation, salinity and current patterns. These studies are very timely as Congress has authorized the deepening of the Baltimore Channels from 42 feet to 50 feet, and studies of the feasibility of deepening the Norfolk Channels are currently being made.

There are some concerns relative to the fiscal and temporal aspects of these studies as, in order to accomplish them, it would be necessary to dismantle and remold portions of the model to deepen the channels. Also, it was noted that the conceptual test designs omitted shoaling type studies and that this was a very important consideration in the decision regarding channel deepening. Including shoaling studies would have a marked influence on costs and time, as the validity of these type studies is highly dependent upon the performance of a detailed shoaling verification of the model. This is a trial and error process which would determine such parameters as the type of materials to be used to simulate the sediment, the method and location of sediment injection and the appropriate magnitudes of tides and freshwater inflows. This is both time consuming and expensive. It was determined, however, that the value of complete studies for Baltimore and Norfolk Harbors would far exceed the costs and time required and that, in fact, each of these programs could be accomplished within the fiscal and temporal allocations for the first year of testing on the hydraulic model of Chesapeake Bay.

The Baltimore and Norfolk Harbor Studies are particularly appropriate applications of hydraulic modeling techniques and would effectively demonstrate the versatility and utility of the hydraulic model of Chesapeake Bay. Both of these studies are widely supported by other public agencies and interested groups and their inclusion in the first year study program was urged by the members of both the Advisory Group and Steering Committee. It was recognized, however, that there is not sufficient monies and time available to perform both of these studies in the first year program and in view of the fact that the Baltimore Harbor Channel deepening is authorized for design and construction, it should have priority over the Norfolk Channels Study.

The North and South Bay Dredged Material Disposal Studies are oriented to determining an optimum location and configuration for open water diked dredged material disposal areas. They would consist of a series of tests which would be designed to assess the changes in tidal heights, salinity distribution and current patterns for a variety of alternative structure locations and shapes. Neither of these tests are very timely, however, as the existing or presently planned disposal sites are adequate to contain the volumes of materials anticipated in the near future. For this reason, both tests were removed from further consideration in the formulation of a first year's study program.

The Potomac River Estuary Water Supply Study is designed to explore the ramifications of using the Potomac River estuary as a supplemental source of water supply for Washington, D.C. The primary concerns generated by this project are changes in the effects on both the salinity regime and flushing characteristics in the upper Potomac River estuary that can result from increased withdrawal of freshwater for water supply during periods of critical low flow. Of concern is the possibility of the recycling of waste water into the water supply system as freshwater inflow decreases and waste water discharges move toward the water supply system inlet. This study represents a particularly appropriate application of hydraulic modeling techniques and will significantly contribute toward the demonstration of the utility and versatility of the hydraulic model.

For both reasons of economy and because of the technical similarity between this test and the Potomac River Estuary Waste Water Dispersal Test, it was decided to combine the two studies into one entitled the Combined Potomac River Estuary Water Supply and Waste Water Dispersal Study.

This combined study will help define the intimate relationship between water supply and waste water disposal for the Potomac River estuary in the Washington, D.C. area. It is important not only in the Chesapeake Bay Study, but to the Corps of Engineers' Metropolitan Washington Water Supply Study which is an ongoing study oriented to solving a critical water supply shortage in the Washington D.C. Metropolitan area. In particular, this study would provide a portion of the data necessary to evaluate one of the prime alternative solutions to the problem, i.e., use of the Potomac Estuary as a water supply source. This study is fully supported by those agencies responsible for furnishing water to the metropolitan area, by other public agencies and interested groups and was specifically requested by representatives of the Mayor of Washington, D.C.

Three thermal effects studies are on the list of high priority candidates for the first year of testing on the hydraulic model of Chesapeake Bay, i.e., the Proposed Upper Bay, the Cumulative Upper Bay, and the Cumulative Lower Bay Power Plant Thermal Effects Studies. There appears to be, however, very little support for the Lower Bay Study and it was consequently removed from further consideration.

The Department of Natural Resources of the State of Maryland is very active in studying potential sites for future power plants and has requested that the hydraulic model be made available for the conduct of several tests. These studies would be oriented to assessing the effects of power plant discharges on temperature, salinity and tidal heights. During discussions between representatives of the Corps of Engineers and the Department of Natural Resources, it was tentatively decided that these studies should be deferred until after the first year of testing is completed.

CHAPTER V

THE FIRST YEAR TESTING PROGRAM

THE SELECTED PROGRAM

From the very beginning of the plan formulation process, it was apparent that nearly all of the identified studies are important areas of high priority and should be included in the first year program of testing on the hydraulic model of Chesapeake Bay. Of course, this is impossible as only three, or at the most four, studies can be accomplished within the established fiscal and temporal constraints. The foregoing plan formulation process was, therefore, conceived as a screening vehicle designed to yield those studies which most nearly met all of the established criteria and consequently would have priority for inclusion in the first year testing program.

In weighing the studies, it was found that the Low Freshwater Inflow, High Freshwater Inflow, Baltimore Harbor Channel Enlargement, and the Combined Potomac Estuary Water Supply and Waste Water Dispersion studies responded about equally to the criteria and that there was high interest in including in the first year program the James and Elizabeth Estuaries Waste Water Dispersion Study. There were not, however, sufficient funds or time available to perform all of these studies and further screening was necessary.

As indicated in the previous chapter, more is known of the impacts of high freshwater inflows than some of other conditions considered and this test was, therefore, reluctantly deferred. It was also recognized that the economic, social, and environmental impacts of the James and Elizabeth Estuaries waste dispersion problems were not as severe as those of some of the other proposed studies and that this test could also be deferred if time and funds were not sufficient to allow its inclusion. Therefore, the tests selected for the first year of testing on the hydraulic model of Chesapeake Bay are the:

a. Low Freshwater Inflow Study
b. Baltimore Harbor Channel Enlargement Study
c. Combined Potomac Estuary Water Supply and Waste Water Dispersion Study

TEST DESIGNS

As previously mentioned, the plan formulation process is an iterative one which normally involves the progressive refinement of data and designs in each step of the process. For the most part, final decisions are made when test designs are still conceptual, but in sufficient detail to allow intelligent analyses and choices. Before the program can be implemented, the selected studies must be extensively refined. This first phase of refinement for the first year program of studies on the Chesapeake Bay Hydraulic Model was accomplished jointly by the Corps of Engineers and the members of the Steering Committee. The work involved consisted of revising the components of the selected tests to include changes which were deemed advisable during the plan formulation process and reviewing and more specifically defining the freshwater inflow and tidal surge characteristics to insure that the tests are responsive to the needs of the decision makers. Descriptions of the detailed test designs are included in Attachment B. An explanation of the more important decisions made during the design period are contained in the following paragraphs. It should be noted, however, that the test designs are subject to change as more information becomes available.

The conceptual form of the Low Freshwater Inflow Study was retained throughout the planning process. The only significant alteration was the deletion of that portion of the study dealing with current velocities and waste dispersion patterns. The primary factors leading to this decision involved cost-benefit considerations. It was found that velocity data would be very expensive to gather in a test of this type and would be of marginal value in achieving one of the overall objectives of the study, i.e., assessing those factors which have a marked influence on the health of the biota of Chesapeake Bay. In addition, although waste water dispersion patterns are important, a meaningful test must be site specific and therefore, studies of this type are not particularly compatible with a general Bay-wide test such as the Low Freshwater Inflow Study.

The freshwater inflow regime was the subject of rather extensive deliberation as it is most important that a proper magnitude and sequence of inflows be selected so as to create in the model the severe drought condition strived for and at the same time be realistic in terms of reflecting a previous natural event or an event with a reasonable probability of occurring in the future. In order to achieve this the following criteria were established:

a. Inflow rates should be a variable natural hydrograph and should be reflective of a natural drought occurrence during which a significant number of riverine tributaries to Chesapeake Bay were continuously monitored.

b. The testing period should be of sufficient length to allow the Bay system to reach stable conditions, to allow salinity levels to reach maximum drought related intensities, and to allow the system to return to a dynamic normality following the drought.

c. Consumptive losses and diversions of water from the Chesapeake Bay basin should reflect realistic projections of future occurrences.

Two rather severe droughts have occurred in the Chesapeake Bay area during the last half century during which tributary rivers were monitored. These were the drought of the thirties (1930-1932) and the drought of the sixties (1961-1966). It was found that although the 1961 to 1966 drought was the longer one, the drought of the thirties was more severe in terms of continuous periods of extremely low freshwater inflows. It was concluded that the 1930 to 1932 drought would be more apt to create the conditions necessary for maximum salinity intrusion to occur. It was also decided that a simulation of three consecutive years is necessary to adequately stabilize the model and to allow the salinity levels to reach maximum drought related intensities. The study would, therefore, begin in calendar year 1929 and extend through calendar year 1931.

In order to determine the length of time required for the salinities of the Bay to return to a dynamic normality, the three drought years will be followed by two average years making a total of five continuous years to be simulated for each phase of the low freshwater inflow study. The freshwater inflows for these two average years were computed by a modal methodology developed by Dr. Donald Pritchard, Johns Hopkins University. This is an averaging technique which allows the retention of the flow magnitude-time relationship characteristics of the natural hydrograph over the period of record.

Projected consumptive losses of water in each of the major tributaries to Chesapeake Bay were computed by applying to the projected water supply demands in each sub-basin factors developed by the Corps of Engineers during conduct of the 1970 Susquehanna River Basin Study. Both the water supply demands and potential out of basin transfers of water were taken from the following comprehensive river basin studies. In the estuary area, projected demands were taken from this report on future conditions.

a. The Susquehanna River Basin Study, U. S. Army Engineer District, Baltimore, 1970.

b. The Potomac River Basin Study, U. S. Army Engineer District, Baltimore, 1963.

c. James River Basin Study, Commonwealth of Virginia, 1971-1972.

d. York River Basin Study, Commonwealth of Virginia, 1972.

e. Rappahannock River Basin Study, Commonwealth of Virginia, 1972.

The scope of the Baltimore Harbor Channels Enlargement Study was expanded considerably at the recommendation of the Advisory Group and Steering Committee. As shown in Attachment B, this revised study will be comprised of a series of hydrodynamic, channel shoaling, and a fate of dredged material deposited in open water tests.

It should be noted, however, that at the time of this writing final decisions have not been made regarding the advisability of conducting the latter two phases of this test. Other methods of ascertaining shoaling rates and the fate of dredged materials deposited overboard are being investigated and should any of these be found more appropriate than model testing, these phases of the test will be deleted.

The freshwater inflows for those portions of the Baltimore Harbor Channels Study dealing with the movement of bottom materials are developed during the conduct of study. This is a trial and error procedure involving varying freshwater inflows until the movement of the material simulating the sediment in the model corresponds to that of the prototype. On the other hand, a 6-month spring-summer average modal hydrograph will be used during the hydrodynamic test so as to optimally reproduce realistic salinity levels and gradients and to provide a condition of comparability with sediment transport mechanisms.

The quantity of freshwater which will flow into the Potomac Estuary during a future drought is primarily a function of the amount of water withdrawn from the Potomac River by local water supply agencies for use in the Washington Metropolitan Area as the water supply intakes for these agencies are above Little Falls and the water is returned to the system near the Anacostia River. It is therefore entirely conceivable that all of the water in the river could be removed for water supply purposes and the flow over Little Falls reduced to zero. In all likelihood this would not be allowed to happen and minimum flow regulations would be established and the flow over Little Falls would in all probability be constant during dry summer and fall months. Consequently, the Combined Potomac Estuary Water Supply and Wastewater Dispersion Study was designed to provide for steady state freshwater inflow conditions. These will be varied over a wide range to facilitate the definition of the movement of the freshwater-saltwater interface and the waste water plume under a variety of freshwater inflow conditions.

COST ESTIMATES

Table 16-3 presents the estimated costs for the first year program of studies on the Chesapeake Bay Hydraulic Model. Included in each study estimate are the costs of labor, salt, photography, data analysis, report writing (separate for Baltimore Harbor Study) and other associated costs. The cost for operation and maintenance of the model complex is that required during the performance of the three selected studies. This estimate includes the costs of labor, utilities, chemicals for the water treatment plant, transportation, supplies, and spare parts required for the normal operation and maintenance of the model. These estimates are October 1976 prices.

FUTURE STUDIES

At the time this report was written only one year of testing on the hydraulic model of Chesapeake Bay was scheduled. The need for studies beyond this time, however, has been evident for years and is particularly accented by both this appendix and the remainder of the <u>Future Conditions Report</u>. The major emphasis in the future, therefore, will be identification of the order in which the many high priority problems of Chesapeake Bay will be addressed on the hydraulic model. The Chesapeake Bay study organization provides a unique opportunity to accomplish this in an atmosphere conducive to the input of nearly all viewpoints. In particular, the Advisory Group and Steering Committee bring together in a forum many of the people not only responsible for making everyday decisions which have great potential influence on the state of Chesapeake Bay, but scientists whose knowledge is a key to intelligent decision making. In addition, the public participation program promotes the inclusion and integration of the viewpoints of those members of the general public interested in Chesapeake Bay. It is hopefully anticipated that all future decisions regarding studies on the hydraulic model of Chesapeake Bay will follow the precedents established in developing the first year of testing, i.e., all decisions will be made in concert between the Corps of Engineers and the members of the Advisory Group, Steering Committee and the public.

TABLE 16-3
CHESAPEAKE BAY HYDRAULIC MODEL
COST ESTIMATE
FIRST YEAR STUDY PROGRAM

LOW FRESHWATER INFLOW STUDY	$ 590,000
BALTIMORE HARBOR CHANNEL ENLARGEMENT STUDY	
Hydrodynamic Test	$ 105,000
Shoaling Verification Test	130,000
Shoaling Base Test	60,000
50' Channel Shoaling Test	60,000
Dredged Fate of Material Test	55,000
Report Preparation	20,000
SUBTOTAL	$ 430,000
POTOMAC ESTUARY WATER SUPPLY AND WASTEWATER DISPERSION STUDY	$ 360,000
TOTAL MODEL TESTING	$1,380,000
OPERATION AND MAINTENANCE	$ 770,000
TOTAL FIRST YEAR STUDY PROGRAM	$2,150,000

ATTACHMENT A

CONCEPTUAL INDIVIDUAL TEST DESCRIPTIONS

TITLE: Chesapeake Bay Low Freshwater Inflow Study

OBJECTIVE: To determine the effects on the Chesapeake Bay System of periods of drought related depressed freshwater inflows

FRESHWATER INFLOWS: Variable Hydrographs

TIDES: Average

DESCRIPTION: The Low Freshwater Inflow Study is Bay wide in scope and will describe the effects on the Chesapeake Bay System of periods of drought related depressed freshwater inflows, such as during the drought periods of 1930-1932 and 1962-1966. Low flow conditions will also be compounded with increasing consumptive losses in upstream drainage basins such as the Susquehanna Drainage Basin. Low freshwater inflows during drought periods can drastically affect salinity conditions imposing environmental stress, and at the same time possibly limiting the spawning opportunity of some species of fish. Periods of low freshwater inflow can also alter existing estuarine flushing characteristics and circulation patterns. This may have widespread waste water dispersion implications. Changes in salinity regime and flushing characteristics will be monitored on the model during the study.

The Low Freshwater Inflow Study will be done in two phases. The first phase will focus on determining how depressed flows from the Susquehanna River will influence the Bay System. This will be done by establishing a sequence of five annual Susquehanna River hydrographs on the model, while at the same time maintaining the average inflow year hydrograph from the remaining tributary areas to the system. The first annual hydrograph, the average freshwater inflow year, will be imposed Bay wide, as well as from the Susquehanna River. This will serve to establish base conditions as well as to provide a bench mark against which to compare change. The second, and succeeding Susquehanna River hydrographs will be the average low flow year, the intermediate low flow year, the extreme low flow year, and finally the average freshwater inflow year. During the entire testing period, model data will be collected and compared with base conditions to determine the extent of change in the estuary with each specific inflow condition. The hydraulic model will be monitored through the final inflow hydrograph period to determine the time required for the system to return to "normal."

Phase 2 of this study will be performed in the same manner as Phase 1, in that again five annual freshwater inflow hydrographs will be imposed on the model. The major difference between Phase 1 and 2 is that the freshwater inflows throughout the whole system will be varied while the Susquehanna River hydrograph is being varied. The sequence of annual inflow hydrographs to be imposed system wide are the average annual inflow year, the average annual low inflow year, the intermediate low flow year, the extreme low flow year, and a return to the average inflow year.

During the entire second phase testing period, model data will be collected and compared with the base conditions to determine the extent of change in the estuary with each specific inflow condition. The hydraulic model will again be monitored through the final inflow hydrograph period to determine the time required for the system to return to normal.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 23 weeks

ESTIMATED STUDY COST: $410,000

TITLE: Chesapeake Bay High Freshwater Inflow Study

OBJECTIVE: To determine the effects on the Chesapeake Bay System of major fluvial flooding

FRESHWATER INFLOWS: Variable Hydrographs

TIDES: Average

DESCRIPTION: This study will be Bay wide in scope and will describe the effects on the Chesapeake Bay System of major fluvial flooding in magnitude equal to the extensive 1936 flooding event. High freshwater inflows can drastically alter existing salinity conditions causing both severe environmental stress and changes in estuarine current patterns and flushing characteristics. The latter condition may have widespread effects on waste water dispersal problems. Also of concern are the public health aspects of the transport into the system of pollutants and refractory compounds by floodwaters. The changes in salinity regime and flushing characteristics, as well as the passage of slugs of freshwater through the estuarine system, will be monitored in the hydraulic model.

This study will be done by establishing in sequence three annual freshwater inflow hydrographs on the model in order to simulate as closely as possible natural conditions occurring within the Bay. The first annual hydrograph will be an average freshwater inflow year to establish base conditions in the model, as well as to provide a bench mark against which to compare change. The second annual hydrograph will be that of the year 1936, the year in which severe flooding occurred on the Susquehanna, Potomac, and James Rivers. Data collected during this portion of the study will be compared with base line model data taken during the average freshwater inflow portion of the study to measure change. The third hydrograph in the study sequence will be a repetition of the average freshwater inflow year. During this portion of the study, the hydraulic model will be monitored to determine the length of time required for the system to return to a period of "dynamic normality."

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 9 weeks

ESTIMATED STUDY COST: $170,000

TITLE: Chesapeake Bay Tidal Flooding Study

OBJECTIVE: The tidal flooding study has two objectives, as follows:

a. Determine the height and extent of flooding due to the 100-year frequency storm surge;

b. Determine the effects of storm surges on the tides, currents, and salinities in the Chesapeake Bay System, as well as the time required for the system to return to normal.

FRESHWATER INFLOWS: Average

TIDES: Storm surge tides

DESCRIPTION: The occurrence of the 100-year tidal flooding event could cause extensive property damage and possibly, loss of life. The Federal flood insurance program, as well as other Federal grant programs, are concerned with the extent and height of flooding due to 100-year frequency events.

This test will require the imposition of three different storm surges on the model in order to simulate the 100-year storm surge in the Lower, Middle, and Upper Bay. Because of this the study will be conducted in three phases. During each phase there will be an average steady state inflow of freshwater. The number of tidal cycles required for the system to return to normal after each surge will be determined. Water surface elevation and salinity data, as well as the areal extent of flooding will be noted during this study.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 14 weeks

ESTIMATED STUDY COST: $510,000

TITLE: Potomac Estuary Water Supply Study

OBJECTIVE: To determine the effects on the hydraulic regime of using the Potomac Estuary as a water supply source

FRESHWATER INFLOWS: Zero from the Potomac River; Average steady state elsewhere

TIDES: Average

DESCRIPTION: The water supply sources for the Washington metropolitan area are not adequate to meet present needs if a drought were to occur. One of the alternative ways of increasing the available amount of water would be the withdrawal of water from the Potomac Estuary. It is not known, however, what effects this would have on salinity, dispersion, and current patterns in the estuary. Of particular concern is the possibility that flow patterns in the estuary would be reversed for a sufficient length of time to allow the salt water wedge and the effluent from the 18 waste water plants discharging to the estuary to reach the water supply intakes. A study using the hydraulic model would be helpful in determining this. A test of this type would be performed in three parts. During all three of these, freshwater inflows in the Potomac River would be assumed to be zero while average steady state inflows would be simulated elsewhere. The first part of the study would consist of a base test representative of conditions if no withdrawal were made. During the second and third parts, plan tests would be conducted reflecting two different levels of withdrawal. In order to assess changes, tidal heights, salinity distributions, and current velocities under each plan condition would be compared to those under base conditions.

Discharges from the 18 waste water treatment plants would be simulated by the injection of appropriate quantities of dyed water into the model at three points. The model would be run a sufficient number of cycles to determine whether or not the waste water would reach the water supply intakes, and if so, how long it would take to reach them.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 6 weeks

ESTIMATED STUDY COST: $105,000

TITLE: Baltimore-Susquehanna Water Supply Diversion

OBJECTIVE: To determine the effects on the Upper Bay hydraulic regime of a decrease in freshwater inflows from the Susquehanna River due to a possible water supply diversion by the City of Baltimore

FRESHWATER INFLOWS: Average low steady state; Depressed low steady state

TIDES: Average

DESCRIPTION: The City of Baltimore is presently dependent upon the Patapsco, Gunpowder, and Susquehanna Rivers for its water supply. It has been projected, however, that these sources, as presently developed, are not sufficient to meet future needs. One of the alternatives for increasing the amount of water available to Baltimore is further development of the Susquehanna River. If this were accomplished, the freshwater discharges of the Susquehanna River would be reduced. This diverted water, however, would, for the most part, be returned to Chesapeake Bay through waste water treatment plants located on the Back and Patapsco Rivers and at the Bethlehem Steel Corporation. A test on the hydraulic model would be particularly useful in determining the effects of this dislocation of freshwater on salinity levels and current patterns in Upper Chesapeake Bay. A test of this kind would be in three parts. The first part would consist of a base test representative of conditions before the diversion was made. During the second part and third part, plan tests would be conducted reflecting two different levels of freshwater diversions to Baltimore. This would be done by decreasing the flows in the Susquehanna River and increasing the discharges from the waste water treatment plants. In order to assess changes, tidal heights, salinity distributions, and current velocities under each plan, conditions would be compared to those under base conditions.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 6 weeks

ESTIMATED STUDY COST: $95,000

TITLE: Proposed Upper Bay Power Plant - Thermal Effects Study

OBJECTIVE: To determine the effects on Chesapeake Bay of thermal discharges from each of three proposed power plants in Maryland

FRESHWATER INFLOWS: Average low steady state

TIDES: Average

DESCRIPTION: The State of Maryland is presently studying the possibility of constructing electrical power generating plants near Port Deposit on the Susquehanna River, Stillpond Neck on the Sassafras River, and Chesapeake City on the Chesapeake and Delaware Canal. The Department of Natural Resources has requested that hydraulic model studies be conducted to assess the potential rises in water temperature in the Bay which may be caused by the discharges of heated water from each of these plants. The study would be conducted in four parts. The first part would consist of a base test representative of conditions without the power plants. During each of the remaining three parts, the heated discharge from one of the power plants would be simulated. In order to assess the changes which may result from the thermal discharges, temperature differentials, salinity patterns, and tidal heights under conditions of power plant operation would be compared with those under base conditions. Also, thermal plume dispersion patterns would be monitored through the use of dye injections.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 5 weeks

ESTIMATED STUDY COST: $80,000

TITLE: Cumulative Upper Bay Thermal Effects Study

OBJECTIVE: To determine both the extent and amount of water temperature increase in the estuary that can occur during the simultaneous discharge of heated water from all existing and proposed electrical power generating plants in the Northern Bay.

FRESHWATER INFLOWS: Average low steady state

TIDES: Average

DESCRIPTION: The State of Maryland is studying both the economic and technical feasibility as well as environmental aspects of the effects of the construction and operation of three power plants in the Upper Bay. The locations of the three proposed plants are (1) Port Deposit, Maryland; (2) along the C & D Canal; and (3) at Still Pond Neck on the Sassafras River. The Maryland State Department of Natural Resources as part of their study program is concerned with not only the cumulative water temperature effects of the three proposed plants, but of the cumulative temperature effects of all of the existing and proposed plants.

The Cumulative Upper Bay Thermal Study will be done in three phases.

Base line data will be collected throughout the Northern Bay portion of the model at all power plant locations during Phase 1 of the study.

During Phase 2, the hydraulic model will be operated with all of the Northern Bay power plant heated discharges simulated. The cumulative thermal effects will be determined through the measurement of water temperature and dye concentration.

The third phase of this study will be done with not only the existing heated discharges simulated in the model, but with the simulated discharges of three proposed plants. This phase of the study will differentiate between the cumulative thermal effects of the existing plants and the three proposed plants. Water temperature and dye dispersion data will be collected as during Phase 2.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 7 weeks

ESTIMATED STUDY COST: $105,000

TITLE: Cumulative Lower Bay Thermal Effects Study

OBJECTIVE: To determine both the extent and amount of water temperature increase in the estuary that can occur during the simultaneous discharge of heated water from all existing and proposed electrical power generating plants in the Southern Bay.

FRESHWATER INFLOWS: Average low steady state

TIDES: Average

DESCRIPTION: A comprehensive plan consisting of all proposed power plants in the Commonwealth of Virginia is now being prepared. Because of the growing number of plants, there is much concern not only of the cumulative water temperature effects of the proposed plants, but of the cumulative temperature effects of all of the existing and proposed plants.

The Cumulative Lower Bay Thermal Effects Study will be done in three phases.

Base line data will be collected throughout the Southern Bay portion of the model at all power plant locations during Phase 1 of the study.

During Phase 2, the hydraulic model will be operated with all of the Southern Bay power plant heated discharges simulated. The cumulative thermal effects will be determined through the measurement of water temperature and dye concentration.

The third phase of this study will be done with not only the existing heated discharges simulated in the model, but with the simulated discharges of the proposed plants. This phase of the study will differentiate between the cumulative thermal effects of the existing plants and the proposed plants. Water temperature and dye dispersion data will be collected as during Phase 2.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 9 weeks

ESTIMATED STUDY COST: $140,000

TITLE: Baltimore Harbor Channel Enlargement Study

OBJECTIVE: To determine the effects of the proposed channel enlargement into Baltimore Harbor on the Chesapeake Bay hydraulic regime

FRESHWATER INFLOWS: Average steady state;
Average low steady state

DESCRIPTION: Congress has authorized the widening and deepening of the Baltimore Harbor Channels. If this project is constructed, dredging must be accomplished in three locations in Chesapeake Bay, i.e., the York Spit Channel, the Rappahannock Shoal Channel, and the areas in and surrounding the Patapsco River. The accomplishment of this project could cause changes in the hydraulic regime of Chesapeake Bay--particularly those factors related to salinity and current patterns. A study on the hydraulic model would be helpful in identifying and possibly minimizing these effects. This study would be performed in four parts. Both of the first two parts would be base tests representative of conditions before the channels are enlarged. During the first part, the model would be operated with average steady state freshwater inflows, while, during the second part freshwater inflows would be reduced to average low steady state conditions. For the third and fourth parts, the model geometry would be revised to reflect the channel enlargements and plan tests performed with freshwater inflows corresponding to those of the base test. In order to assess change, tidal heights, salinity distributions, and current velocities under each plan would be compared to those under base conditions.

MODEL GEOMETRY: Revised

ESTIMATED STUDY TIME: 16 weeks

ESTIMATED STUDY COST: $230,000

TITLE: North Bay Dredge Material Disposal Study

OBJECTIVE: To determine an optimum location and configuration for an open water, diked dredged material disposal area in the northern portion of Chesapeake Bay

FRESHWATER INFLOWS: Average low steady state

TIDES: Average

DESCRIPTION: Congress has authorized the widening and deepening of the access channels to Baltimore Harbor. If this project is constructed, a disposal site for dredged material must be provided. To accomplish this, the State of Maryland has recommended an open water, diked disposal site at Hart and Miller Islands. The structure to be initially constructed, however, is not of sufficient size to accommodate all of the material anticipated from construction and maintenance, and an addition site must be ultimately provided. One alternative for this is another open water, diked disposal area. These type facilities, however, tend to change the hydraulic regime of the surrounding water body and should be located so as to minimize adverse effects. Consequently, studies on the hydraulic model would be useful in determining an appropriate site and configuration for such a structure. This study would be in two parts. The first part would consist of a base test representative of conditions without the diked area, while, the second part would consist of a series of plan tests designed to identify an appropriate location and shape of structure. It is anticipated that five alternative sites and three configurations at each site would be studied. In order to assess changes, tidal heights, salinity distributions, and current velocities under each plan condition would be compared to those under base conditions. Also, dye dispersion studies would be made during the plan tests to ascertain the fate of any pollutants which may escape through the overflow structure.

MODEL GEOMETRY: Revised

ESTIMATED STUDY TIME: 16 weeks

ESTIMATED STUDY COST: $230,000

TITLE: Norfolk Harbor Channel Enlargement Study

OBJECTIVE: To determine the effects of the proposed channel enlargement into Norfolk Harbor on the Chesapeake Bay hydraulic regime

FRESHWATER INFLOWS: Average steady state;
Average low steady state

DESCRIPTION: The widening and deepening of the Norfolk Harbor Channels is now under study. If this project is constructed, dredging must be accomplished in the James River. The accomplishment of this project could cause changes in the hydraulic regime of Chesapeake Bay--particularly those factors related to salinity and current patterns. A study on the hydraulic model would be helpful in identifying and possibly minimizing these effects. This study would be performed in four parts. Both of the first two parts would be base tests representative of conditions before the channels are enlarged. During the first part, the model would be operated with average steady state freshwater inflows, while, during the second part freshwater inflows would be reduced to average low steady state conditions. For the third and fourth parts, the model geometry would be revised to reflect the channel enlargements and plan tests performed with freshwater inflows corresponding to those of the base test. In order to assess change, tidal heights, salinity distributions, and current velocities under each plan would be compared to those under base conditions.

MODEL GEOMETRY: Revised

ESTIMATED STUDY TIME: 10 weeks

ESTIMATED STUDY COST: $155,000

TITLE: South Bay Dredge Material Disposal Study

OBJECTIVE: To determine an optimum location and configuration for an open water, diked dredged material disposal area in the southern portion of the Chesapeake Bay

FRESHWATER INFLOWS: Average low steady state

TIDES: Average

DESCRIPTION: The possibility of deepening and widening the access channels to the Norfolk and York River Harbors is now being studied. If the findings are favorable and either one of the projects constructed, a disposal site for the dredged material must be identified. One alternative for this is an open water diked disposal area. These type facilities, however, tend to change the hydraulic regime of the surrounding water bodies and should be located and structured so as to minimize adverse effects. Consequently, studies on the hydraulic model would be useful in determining an appropriate site and configuration for a disposal area. This study would be in two parts. The first part would consist of a base test representative of conditions without the diked area, while, the second part would consist of a series of plan tests designed to identify an appropriate location and shape of the structure. It is anticipated that three alternative sites and three configurations at each site would be studied. In order to assess changes, tidal heights, salinity distributions, and current velocities under each plan condition would be compared to those under base conditions. Also, dye dispersion studies would be made during the plan tests to ascertain the fate of any pollutants which may escape through the overflow structures.

MODEL GEOMETRY: Revised

ESTIMATED STUDY TIME: 18 weeks

ESTIMATED STUDY COST: $250,000

TITLE: York Harbor Channel Enlargement Study

OBJECTIVE: To determine the effects of the proposed channel enlargement into York Harbor on the Chesapeake Bay hydraulic regime

FRESHWATER INFLOWS: Average steady state;
Average low steady state

DESCRIPTION: The possibility of widening and deepening the York Harbor Channels is now under study. If this project is constructed, dredging must be accomplished in the York River. The accomplishment of this project could cause changes in the hydraulic regime of Chesapeake Bay--particularly those factors related to salinity and current patterns. A study on the hydraulic model would be helpful in identifying and possibly minimizing these effects. This study would be performed in four parts. Both of the first two parts would be base tests representative of conditions before the channels are enlarged. During the first part, the model would be operated with average steady state freshwater inflows, while, during the second part freshwater inflows would be reduced to average low steady state conditions. For the third and fourth parts, the model geometry would be revised to reflect the channel enlargements and plan tests performed with freshwater inflows corresponding to those of the base test. In order to assess change, tidal heights, salinity distributions, and current velocities under each plan would be compared to those under base conditions.

MODEL GEOMETRY: Revised

ESTIMATED STUDY TIME: 8 weeks

ESTIMATED STUDY COST: $115,000

TITLE: Potomac River Waste Water Dispersion Study

OBJECTIVE: To determine how waste water effluents from existing treatment plants are dispersed in the tidal portion of the Potomac River and its tributaries

FRESHWATER INFLOWS: Average steady state; Low steady state

TIDES: Average

DESCRIPTION: There are 18 major waste water treatment plants presently discharging their effluent into the tidal portion of the Potomac River and its tributaries. If sufficient concentrations of these wastes are present in the water bodies, severe alterations to the ecological system could occur. For instance, the more lethal constituents of the waste waters could cause fish mortalities or large concentrations of nutrients could accelerate the eutrophication process. On the other hand, the costs of advanced waste water treatment are very high and it is desirable to have available data which would allow a determination of those treatment levels which balance economic and environmental costs. An important consideration in this is the manner in which waste waters are assimilated and dispersed in the estuary system. This can be readily determined through a hydraulic model test.

In this test, the waste water discharges would be simulated in the model by adding, at each treatment plant location, quantities of dyed freshwater equivalent to its average daily discharge. The model will be operated a sufficient number of cycles to allow complete dispersion of the dye.

The study will be done in two parts so as to provide data representative of a range of freshwater inflow conditions. The first part will simulate conditions when average freshwater inflows from the fluvial river tributaries are occurring.

During the second part, freshwater inflows will be reduced to those expected under low steady state conditions. During the study, tidal heights, salinity distributions, current velocities, and dye dispersion will be monitored.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 5 weeks

ESTIMATED STUDY COST: $85,000

TITLE: Patuxent River Waste Water Dispersion Study

OBJECTIVE: To determine how waste water effluents from existing treatment plants are dispersed in the tidal portion of the Patuxent River and its tributaries

FRESHWATER INFLOWS: Average steady state; Low steady state

TIDES: Average

DESCRIPTION: There are 15 waste water treatment plants presently discharging their effluent into the tidal portion of the Patuxent River and its tributaries. If sufficient concentrations of these wastes are present in the water bodies, severe alterations to the ecological system could occur. For instance, the more lethal constituents of the waste waters could cause fish mortalities or large concentrations of nutrients could accelerate the eutrophication process. On the other hand, the costs of advanced waste water treatment are very high and it is desirable to have available data which would allow a determination of those treatment levels which balance economic and environmental costs. An important consideration in this is the manner in which waste waters are assimilated and dispersed in the estuary system. This can be readily determined through a hydraulic model test.

In this test, the waste water discharges would be simulated in the model by adding, at each treatment plant location, quantities of dyed freshwater equivalent to its average daily discharge. The model will be operated a sufficient number of cycles to allow complete dispersion of the dye.

The study will be done in two parts so as to provide data representative of a range of freshwater inflow conditions. The first part will simulate conditions when average freshwater inflows from the fluvial river tributaries are occurring.

During the second part, freshwater inflows will be reduced to those expected under low steady state conditions. During the study, tidal heights, salinity distributions, current velocities, and dye dispersions will be monitored.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 5 weeks

ESTIMATED STUDY COST: $80,000

TITLE: James and Elizabeth Rivers Waste Water Dispersion Study

OBJECTIVE: To determine how waste water effluents from existing treatment plants are dispersed in the tidal portion of the James River and its tributaries

FRESHWATER INFLOWS: Average steady state; Low steady state

TIDES: Average

DESCRIPTION: There are 16 major waste water treatment plants presently discharging their effluent into the tidal portion of the James River and its tributaries. If sufficient concentrations of these wastes are present in the water bodies, severe alterations to the ecological system could occur. For instance, the more lethal constituents of the waste waters could cause fish mortalities or large concentrations of nutrients could accelerate the eutrophication process. On the other hand, the costs of advanced waste water treatment are very high, and it is desirable to have available data which would allow a determination of those treatment levels which balance economic and environmental costs. An important consideration in this is the manner in which waste waters are assimilated and dispersed in the estuary system. This can be readily determined through a hydraulic model test.

In this test, the waste water discharges would be simulated in the model by adding, at each treatment location, quantities of dyed freshwater equivalent to its average daily discharge. The model will be operated a sufficient number of cycles to allow complete dispersion of the dye.

The study will be done in two parts so as to provide data representative of a range of freshwater inflow conditions. The first part will simulate conditions when average freshwater inflows from the fluvial river tributaries are occurring.

During the second part, freshwater inflows will be reduced to those expected under low steady state conditions. During the study, tidal heights, salinity distributions, current velocities, and dye dispersion will be monitored.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 7 weeks

ESTIMATED STUDY COST: $105,000

TITLE: Patapsco River Waste Water Dispersion Study

OBJECTIVE: To determine how the waste water effluents from the Patapsco River treatment plant are dispersed in the Patapsco River and the Upper Bay

FRESHWATER INFLOWS: Average steady state; Low steady state

TIDES: Average

DESCRIPTION: The City of Baltimore is presently planning a rather large expansion of the Patapsco River Waste Water Treatment Plant. When completed, this plant will discharge rather large volumes of treated wastes to the tidal portion of Patapsco River. If sufficient concentrations of these wastes are present in the water body, severe alterations to the ecological system could occur. For instance, the more lethal constituents of the waste waters could cause fish mortalities or large concentrations of nutrients could accelerate the eutrophication process. On the other hand, the costs of advanced waste water treatment are very high and it is desirable to have available data which would allow a determination of those treatment levels which balance economic and environmental costs. An important consideration in this is the manner in which waste waters are assimilated and dispersed in the estuary system. This can be readily determined through a hydraulic model test.

In this test, the waste water discharges would be simulated in the model by adding, at the plant, a quantity of dyed freshwater equivalent to its average daily discharge. The model will be operated a sufficient number of cycles to allow complete dispersion of the dye.

The study will be done in two parts so as to provide data representative of a range of freshwater inflow conditions. The first part will simulate conditions when average freshwater inflows from the fluvial river tributaries are occurring.

During the second part, freshwater inflows will be reduced to those expected under low steady state conditions. During the study, tidal heights, salinity distributions, current velocities, and dye dispersion will be monitored.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 5 weeks

ESTIMATED STUDY COST: $80,000

TITLE: Back River Waste Water Dispersion Study

OBJECTIVE: To determine how the waste water effluents from the Back River treatment plant are dispersed in the Back River and the Upper Bay

FRESHWATER INFLOWS: Average steady state; Low steady state

TIDES: Average

DESCRIPTION: The Back River Water Pollution Control Plant is the major waste water treatment plant serving the City of Baltimore. It discharges large volumes of treated wastes to the tidal portion of Back River. If sufficient concentrations of these wastes are present in the water body, severe alterations to the ecological system could occur. For instance, the more lethal constituents of the waste waters could cause fish mortalities or large concentrations of nutrients could accelerate the eutrophication process. On the other hand, the costs of advanced waste water treatment are very high and it is desirable to have available data which would allow a determination of those treatment levels which balance economic and environmental costs. An important consideration in this is the manner in which waste waters are assimilated and dispersed in the estuary system. This can be readily determined through a hydraulic model test.

In this test, the waste water discharges would be simulated in the model by adding, at the plant, a quantity of dyed freshwater equivalent to its average daily discharge. The model will be operated a sufficient number of cycles to allow complete dispersion of the dye.

The study will be done in two parts so as to provide data representative of a range of freshwater inflow conditions. The first part will simulate conditions when average freshwater inflows from the fluvial river tributaries are occurring.

During the second part, freshwater inflows will be reduced to those expected under low steady state conditions. During the study, tidal heights, salinity distributions, current velocities, and dye dispersion will be monitored.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 5 weeks

ESTIMATED STUDY COST: $80,000

TITLE: Combined Potomac River Estuary Water Supply and Waste Water Dispersion Studies

OBJECTIVES: The objectives of the combined study are to determine the changes in both the salinity regime and the patterns of dispersion of waste water discharged into the tidal portion of the Potomac River in the Washington, D.C., area resulting from using the estuary as a supplemental source of water for Washington. Of particular importance will be the investigation of the possibility of recirculation of waste water from the 18 waste water treatment plants outfalling into the area back into the proposed metropolitan water supply during periods of low and zero freshwater inflow.

FRESHWATER INFLOWS: Average, low flow, and zero flow

TIDES: Average

DESCRIPTION: The two tests were combined for both reasons of economic efficiency and the timeliness of the problems. The initial testing procedure will be to establish a base-line evaluation of salinity distribution and patterns of dispersion of waste water discharges during periods of average freshwater inflow and tidal conditions. Waste water dispersion patterns will be determined through the use of dye injected into the model at preselected locations.

The next phase of the study will be the collection of salinity, current velocity, tidal elevation, and dye concentration data to describe the impact on the estuary of a sequence of simulated low freshwater inflow and pumped withdrawals of freshwater for water supply purposes. This data will be collected during each of the following sequence of steady state model freshwater inflow conditions.

1. Low Freshwater Inflow
2. Zero Freshwater Inflow
3. Zero Freshwater Inflow combined with a 100 mgd pumped withdrawal
4. Zero Freshwater Inflow combined with a 200 mgd pumped withdrawal

The data collected during each of the above steady state inflow conditions will be compared to that collected during the average freshwater inflow condition to determine the amount of estuarine change, and if there is, in fact, danger of the recirculation of waste water into the Washington, D. C., water supply system.

MODEL GEOMETRY: Existing

ESTIMATED STUDY TIME: 10 weeks

ESTIMATED STUDY COST: $190,000

ATTACHMENT B

DESIGN OF FIRST YEAR HYDRAULIC STUDIES

TITLE: Chesapeake Bay Low Freshwater Inflow Study

PROBLEM: It is well recognized that the freshwater flowing into Chesapeake Bay exerts a profound effect, both physically and ecologically, throughout the estuarine system. Of particular concern to the managers and planners in the Chesapeake Bay Area are the combined effects on the system of greatly depressed freshwater inflows due to drought; projected municipal, industrial, and agricultural consumptive water losses; and the possibility of future diversions of significant amounts of freshwater out of the Chesapeake Bay Drainage Basin.

OBJECTIVE: To determine the response of the Chesapeake Bay System to depressed freshwater inflows due to both drought and increased consumptive losses with emphasis on developing time histories of tidal elevations and salinity concentrations for specified low flow conditions and to determine the time for the system to return to a state of dynamic normalcy.

FRESHWATER INFLOWS: A weekly hydrograph (prototype) will be imposed on the model, simulating three years of drought flow and two years of average inflow. In addition, the three years of drought will be depressed by projected consumptive losses.

TIDES: Average

TEST PROCEDURE: The Low Freshwater Inflow Study is divided into three parts as follows, each part to be done in the indicated order:

1. Base Conditions Test
2. First Plan Test
3. Second Plan Test

The numbered individual tests shown above are designed to first determine bench mark salinity conditions in the estuarine system during periods of specified low flow, followed by the determination of the effects on the salinity and tidal regime in the estuary resulting from greatly depressed freshwater inflows. The final step in the study will be to define the effect on the system of depressed freshwater inflow of the Susquehanna River alone.

To establish the bench mark salinity regime in the Chesapeake Bay Model during the Base Conditions Test, a sequence of five Bay-wide weekly annual freshwater inflow hydrographs will be simulated at twenty-one selected model freshwater inflow points. The five year hydrograph will consist of the low flow years 1929-1931 followed by two years of average freshwater inflow.

During the First Plan Test the basin wide annual weekly hydrograph for the years 1929-1931 will be combined with both projected consumptive losses and out basin diversions and then simulated in the model. These depressed low flow hydrographs will again be followed by two years of the weekly annual Baywide average freshwater inflow hydrographs. Data from this test will be compared with that from the Base Conditions Test in order to both determine the effects on the salinity regime of the estuary of the depressed low flows and estimate the time required for the salinity regime of the system to return to normal.

The Second Plan Test will be accomplished in much the same manner as the previous test in that again five weekly annual hydrographs will be introduced into the model. During this test, however, only the Susquehanna River hydrograph will be depressed, while the remaining basin-wide freshwater inflows will be of the same magnitude of those used during the Base Conditions Test. Data collected from the model during this experiment will be again compared with the Base Conditions Test in order to determine the effects on the system of the Susquehanna River alone.

MODEL DATA COLLECTION: Throughout this study, several stations on the model will be continuously monitored to ensure that the model is operating properly. For study purposes water surface elevation and salinity data will be collected at many other appropriate points on the model. Because of the large size of the model and limitations on the quantity of available personnel as well as instrumentation, the model will be divided into three sections for the collection of data during both the Base Conditions and First Plan Tests. This will necessitate the replication of both of these tests three times. During the Second Plan Test, that explores the effect of the Susquehanna River on the system, salinity and tidal data collection will be concentrated in the upper portion of the Bay, necessitating only one replication of this test.

A time history of salinity change and tidal elevations will be developed for each of the three freshwater inflow conditions used in this study. The time histories developed during the First and Second Plan Studies will be compared with that of the Base Conditions Test and with each other to define change in the system due to different inflow conditions and the time required for the system to return to its original state.

ESTIMATED STUDY TIME: 29 weeks

ESTIMATED STUDY COST: $590,000

TITLE: Baltimore Harbor Channel Enlargement Study

PROBLEM: Congress has authorized the enlargement of the navigation channels leading to Baltimore Harbor. Dredging will be done in the channels in the northern and southern portions of the Bay as well as the Patapsco River. The channel changes may bring about significant hydraulic changes in the system affecting waste dispersion and salinity distribution. Historically, the enlargement of navigation channels in Baltimore Harbor has also been accompanied by increased maintenance dredging.

OBJECTIVES: The objectives of this study are to determine the effects of the proposed channel enlargement of the Baltimore Harbor Channels on the hydraulic regime of the Bay; to determine the deposition patterns of dredged material placed in open water in the vicinity of the enlarged channels; and to make an assessment of future dredging required to remove shoaling material from the enlarged channels.

FRESHWATER INFLOWS: During the hydrodynamic phase of the study, a six month weekly hydrograph simulating average spring and summer freshwater inflows into the system will be imposed on the model. During the remaining phases, a steady-state inflow will be used, the magnitude of which will be dependent upon the shoaling verification test.

TIDES: Average

TEST PROCEDURE: This study is divided into two parts as follows:

A. 42-foot Channel Base Conditions, including
   1. Hydrodynamic Base Test
   2. Shoaling Verification Test
   3. Shoaling Base Test

B. 50-foot Channel Plan Conditions, including
   4. Hydrodynamic Plan Test
   5. Shoaling Plan Test
   6. Fate of Dredged Materials Test

The numbered individual tests shown above are designed to first determine hydrodynamic and shoaling conditions in the existing 42-foot navigation channels, and then to project change that will result from the construction of the proposed 50-foot channel project. Comparison of the data derived from both the 42-foot Channel Base Conditions and 50-foot Plan Conditions Series of tests will determine the change due to the construction of the 50-foot channel.

During the course of the Hydrodynamic Base Test (#1) water surface elevation, current velocity, and salinity data will be collected in order to establish bench mark conditions for the existing 42-foot channel. After the proposed 50-foot channel is installed in the model, the Hydrodynamic Test will be repeated and water surface elevation, current velocity, and salinity data will again be collected in the same locations in order to define change in these parameters.

The Shoaling Verification Test (#2) is particularly important in that various combinations of tidal elevations, freshwater inflow conditions, and plastic particles simulating shoaling material will be analyzed in order to develop a model operating mode that will be used throughout each shoaling study. The Shoaling Base Test (#3) will be a replication of the Shoaling Verification Test, except that many more precise measurements of volumes of shoaling material will be made to accurately establish bench mark shoaling conditions. The Shoaling Plan Test (#5) will involve injecting shoaling material into the model and noting the quantities and distribution of material resulting from construction of the 50-foot channel for comparison with those of the 42-foot existing channel.

The last test of the Baltimore Harbor Study is the Dredged Fate Material Test. Material simulating native dredged material will be placed in the model in proposed areas of deposition during construction. The hydraulic model will then be operated until movement of the material ceases. Comparison will be made of the material remaining in place and that material transported.

MODEL DATA COLLECTION: Throughout this study, several stations on the model will be continuously monitored to ensure that the model is operating properly. Water surface elevation, current velocity, and salinity data will be collected in appropriate areas of the model during the hydrodynamic tests. Data collection stations will be more concentrated in the Baltimore Harbor Area. Shoaling data will be collected by both volumetric and photographic techniques during the shoaling tests.

MODEL GEOMETRY: The proposed 50-foot channel will be molded into the model.

ESTIMATED STUDY TIME: 24 weeks

ESTIMATED STUDY COST: $430,000

TITLE: Combined Potomac River Estuary Water Supply and Waste Water Dispersion Study

PROBLEM: During periods of low flow from the Potomac River it may become necessary to supplement the Washington, D. C., municipal water supply with water pumped from the Potomac River Estuary. Presently there are eighteen waste water treatment plants discharging into the Potomac River Estuary in the Washington Area. Of particular concern is the possibility of effluent from these plants migrating to the water supply inlet while pumping water from the estuary. Further, there has been concern expressed as to the effect pumping freshwater would have on the salinity regime and flushing patterns of the estuary.

OBJECTIVES: The objectives of this study are to define the salinity regime and waste water dispersion patterns in the Upper Potomac River Estuary under several freshwater inflow conditions and to determine the impact of pumping water out of the Upper Potomac River Estuary at Washington, D. C., upon both salinities and overall waste water dispersion patterns.

FRESHWATER INFLOWS: Steady-state freshwater inflows of various magnitudes into both the Potomac River Estuary and the remainder of the model freshwater inflow points.

TIDES: Average

TEST PROCEDURE: Before starting into this series of tests, it will be necessary to do a short preliminary dye dispersion study in order to determine the area of influence of the known waste water discharges, thereby both enabling the optimization of the location of the network of model data collection stations and establishing model sampling schedules.

The study proper is divided into four parts as follows:

A. A steady-state monthly average inflow for the months of July through November, 1930, will be discharged into all model tributaries.

B. Discharges of 100, 250, and 400 mgd into the model through the Potomac River. The 50-year 7-day low flow for each individual tributary will be discharged into the model from the remaining model freshwater inflow points. A dye discharge into the model will be used to simulate the waste water discharges into the system from the existing waste water treatment plants.

C. Discharges of 100, 250, and 400 mgd into the model through the Potomac River. The 50-year 7-day low flow for each individual tributary will be discharged into the model from the remaining model freshwater inflow points. A 100 mgd pumped withdrawal from the Upper Potomac River Estuary will simulate water supply needs for Washington, D. C.

D. Discharges of 100, 250, and 400 mgd into the model through the Potomac River. The 50-year 7-day low flow for each individual tributary will be discharged into the model from the remaining model freshwater inflow points. A 200 mgd pumped withdrawal from the Upper Potomac River Estuary will simulate water supply needs for Washington, D. C.

The purpose of Part A of the above test series is to describe how the Upper Potomac River Estuary salinity regime responded to drought flows of the 1930's, lending historical perspective to this study.

Data collected from the model during Part B will be used to establish salinity and waste water dispersion patterns resulting from 100, 250, and 400 mgd freshwater inflows into the estuary. This test will establish the bench mark conditions against which data collected during Parts C and D will be compared.

During Parts C and D the same freshwater inflow conditions used during Part B will be replicated in the model, as noted previously. In addition, pumped withdrawals of 100 and 200 mgd will be simulated. Data from these tests will indicate changes in salinity and waste water dispersion patterns that will result from the imposition of the pumped water supply withdrawal for each specified discharge from the Potomac River. From these two tests it will also be possible to determine if, in fact, waste water will migrate to the water supply inlet and estimate the time required for this to happen.

MODEL DATA COLLECTION: Throughout this study several stations on the model will be continuously monitored to ensure that the model is operating properly. Data collection, consisting of salinity and dye concentration sampling as well as tidal elevation measurements, will be concentrated in the Upper Potomac River Estuary. As the major concerns of this study are both salinity changes and waste water dispersion, no velocity data will be collected.

ESTIMATED STUDY TIME: 17 weeks

ESTIMATED STUDY COST: $360,000