Forecasting Economic Impacts of The Boston Harbor Cleanup

by

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ABSTRACT

We used the Boston Metro Two-Area Forecasting and Simulation Model to assess the economic repercussions of the environmental policy to clean up Boston Harbor. To forecast the impacts of the environmental policy change, we used estimates of proposed annual construction expenditures from the Massachusetts Water Resources Authority and estimates of annual increases in recreational use of Boston Harbor from META Systems, Inc.

The results of the forecasts from the Boston Model for the period 1987 to 2010 indicated that new construction investments and increased recreational activity will stimulate significant increases in local employment and output, particularly in the services and retail trade sectors; manufacturing will experience some of the smallest gains in employment and output. Export of locally produced goods and services will decline and inflation will increase. The beneficial effects of the environmental policy will be sustained in the long-term.

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I take full responsibility for all errors and ommissions in this thesis.

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Chapter 1

Introduction

Boston residents and public officials have known for a long time about wastewater pollution in Boston Harbor. Even as early as the 1800s, Boston's officials worried about the consequences to the Harbor and its surrounding communities of improper municipal waste disposal. At that time, the City's sewage disposal system consisted of emptying untreated domestic and industrial wastewater directly in the Harbor. In later years, researchers documented the continued inadequacy of municipal waste disposal and the consequent degradation of water quality in Boston Harbor. In a 1939 study, analysts recommended that primary sewerage treatment plants be built at Deer Island, Nut Island, and Moon Island; however, it was not until 1952 and 1968 that plants were built at Nut Island and Deer Island, respectively. No plant was ever built at Moon Island (Haar, 1986, p. viii).

Today, most people in the United States know of Boston Harbor as the most severely polluted harbor in the country. Boston's sewage disposal system, which is responsible for this pollution, needs extensive repairs and is unable to keep pace with the growth and prosperity in metropolitan Boston. Consequently, an average of 450 million gallons per day of raw and partially treated sewage empties into the Harbor from the primary sewage treatment plants at Deer Island and Nut Island.

Also, according to the Massachusetts Water Resources Authority (MWRA), outfall pipes located along the Harbor shoreline and along the Charles River, Mystic River, and Neponset River, empty another 5 to 10 billion gallons of raw sewage and stormwater runoff into the Harbor each year (MWRA, 1988, p. 8).

It is primarily these two sources of pollution that make Boston Harbor unsafe for swimming and fishing, and for adequately supporting ecological life. High levels of fecal coliform (a bacterial indicator of domestic sewage pollution), toxic chemicals, and heavy metals, such as copper, mercury, and nickel, jeopardize the water quality of the Harbor. In addition, these pollutants contaminate beaches and shellfish beds in the Harbor, particularly in Dorchester Bay and Quincy Bay. They also destroy the abundance and variety of aquatic life existing in the Harbor.

Just as the pollution in Boston Harbor is no secret, the high cost of improving the water quality of the Harbor comes as no surprise either. Since the 1970s, analysts have estimated the cost of cleaning up Boston Harbor. In 1977, they showed that the cleanup would have cost $800 million, with local communities in the metropolitan area paying $80 million of that cost (Dumanoski, 198_, p. 82). Today, MWRA staff (1988) estimate that court-ordered construction of new facilities to end wastewater pollution will cost approximately $6.1 billion (in 1990 dollars), with local communities paying the majority of the bill. MWRA will distribute the costs, through sharp increases in user rates, among the 43 communities using the area's sewage facilities; for example, current user rates for both sewer and water services[1] will increase from $200 per year to more than $1,000 per year by the year 2000 (Tyre, 1988, p. 1). Ratepayers in the metropolitan area strongly oppose these sharp rate increases that have already dramatically increased their current tax payments.

For these sharp rate increases, local community residents expect much more than an efficient sewage disposal system. The majority of residents, who use the Harbor for recreation and business activities or who simply value the existence of a clean Harbor environment, expects additional benefits, such as cleaner and safer beaches, increased recreational use of the Harbor, seafood that is less contaminated, and an environment that is more aesthetically appealing. In a 1985 study by META Systems, Inc.[2] (META), META staff estimate what these benefits to society might be if water quality in Boston Harbor is restored to the levels mandated by the Federal policy. META

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[1]We do not have separate estimates of rate increases for each service; however, sewer upgrading represents more than 90% of the total MWRA capital improvement budget.

[2]META Systems, Inc. is an environmental consulting group that produced a study for the Environmental Protection Agency entitled, "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements From Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls."

staff show that, as water quality improves, the following beneficial outcomes are most likely to occur:

1) swimming, boating and recreational fishing in the Harbor will increase;
2) commercial fishing activity will increase as closed shellfish beds reopen for harvesting and the outer Harbor waters are cleansed;
3) swimming-related illnesses and shellfish-consumption illnesses will decline leading to savings in medical expenses; and
4) ecological processes in Boston Harbor will be restored as concentrations of toxic pollutants decline.

Although Boston's residents are aware of the potential for these health, environmental, and aesthetic benefits described by META analysts, they are less aware of the resulting beneficial economic repercussions of these benefits. In the short-run, construction expenditures will stimulate economic activity throughout the local economy. As investment in construction increases, direct and indirect inputs into construction will also increase; for example, because services represent a large input into construction, construction investments will increase employment and output in the services sector. Furthermore, given that services industries supply the largest share of employment and the second largest share of output in the metropolitan economy, the increases in employment and output in this sector due to investment in construction are likely to be significant. As employment opportunities in the local economy increase, workers will be drawn to the area from other parts of the state and from neighboring states, as well. These workers will demand consumer products, such as clothing, video cassette recorders, and furniture; consequently, output and employment in retail trade establishments will increase to satisfy these new demands.

In the long-run, operation of the pollution control facilities will lead to increased recreation and business activity in Greater Boston. An increase in the numbers of local residents and tourists that are drawn to the Harbor, and the growth of new businesses, will stimulate local demand for retail products, such as food, fishing and boating equipment, and clothing; services, such as hotel and motel, personal and repair, and amusement and recreation; and financial services, such as real estate, banking, insurance, and investment. As a result, employment will increase.

These examples we have described illustrate some of the beneficial economic repercussions of the Harbor cleanup; however, the Harbor cleanup will have negative economic consequences as well. Manufacturing, which does not represent a large input into construction and is declining in relative importance in the local economy, will suffer losses in employment and output as resources are drawn away from manufacturing industries. Additionally, rising prices as a result of increasing regional demand will lead to an increase in the rate of inflation in the metropolitan economy.

In this thesis, we will assess these economic repercussions of the Boston Harbor cleanup. Specifically, we will quantify the changes in economic activity in the metropolitan economy due to investments in construction and increases in recreation. We will simulate these two phases of the cleanup process by using MWRA estimates of proposed construction expenditures and META estimates of the increase in benefits to those who use the Harbor for recreation activities. We will consider neither the effects of financing the cleanup nor the effects of increased sewer rates on the local economy.

To conduct our economic impact analysis of the pollution control policy, we will use the region-specific Boston Forecasting and Simulation Model, hereafter referred to as the Boston Model (Treyz, 1986). We were granted permission by George I. Treyz to use the model, and it was provided to us by Alexander Ganz of the Boston Redevelopment Authority. The Boston Model is a multi-area, macroeconomic forecasting tool that allows determination of economic impacts of policy recommendations. Because it accounts for the interaction between Suffolk County and the rest of the Boston metropolitan region, we can determine the economic effects on the metropolitan area of the court-ordered cleanup. Construction expenditures for new pollution control facilities will stimulate economic activity in Suffolk County, which will then stimulate economic activity in the rest of metropolitan Boston. This extra activity in the rest of metropolitan Boston will, in turn, lead to new demands for goods and services in Suffolk county. We will present a description of the Boston Model in the third chapter and we will discuss some advantages of this model relative to other economic impact models.

By conducting an economic impact analysis of the Harbor cleanup, we will show that the program can generate significant increases in local economic activity. We believe that our analysis can be useful for developing economic and management policies for the local area and for Boston Harbor. Furthermore, we believe that the results of our analysis can be used by local decision-makers to capitalize on opportunities for new business and employment induced by the cleanup and to plan for expected declines in certain industrial sectors.

The Boston metropolitan area is not typical of metropolitan areas throughout the United States in terms of size, climate, and economic characteristics; therefore, our results cannot be used to make predictions about economic repercussions in other cities. Even so, they can provide valuable insights about the economic effects of environmental policies for achieving improved water quality that go beyond the benefits to direct users of a water resource. We hope that the results of our analysis can be used to support the implementation of water pollution control policies in other coastal cities in the United States.

Following is a brief description of the contents of this thesis. In the second chapter, we will present a brief discussion of the conceptual basis for estimating the benefits of water-quality improvements. We will describe two measurement techniques that analysts use to estimate these benefits--the travel cost method and the contingent valuation method. Then, we will summarize the findings of the study by META Systems, Inc. and present their benefit estimates for improved water quality in Boston Harbor.

In the third chapter, we will describe the Boston Forecasting and Simulation Model and how we will use it to simulate the impacts of the environmental policy. Before we discuss the results of the forecast, we will characterize the Boston metropolitan economy in Chapter four, paying particular attention to its high employment and output sectors, occupational employment, and local relative production costs. In Chapter five, we will analyze the economic impacts of the Harbor cleanup policy over the period 1987 to 2010. In Chapter six, the final chapter, we will present our summary and conclusions.

Chapter 2

Benefits of Water-Quality Improvement

In this chapter, we present briefly the conceptual basis for estimating the benefits from water-quality improvement. In this thesis, when we refer to benefits, we mean the "benefits" component of a benefit-cost analysis and, more specifically, the gross benefits to those in the metropolitan area on whose behalf the environmental project is undertaken. We do not intend to conduct a benefit-cost analysis of the Boston Harbor cleanup; thus, we do not take into account the economic costs, in terms of the required resources that could have been employed in other useful ways. Given that estimates of gross benefits were the only ones available to us at the time of our study, we use them and we will assess their economic repercussions on the metropolitan area.

We describe two approaches commonly used by analysts to measure the social benefits of water-quality improvement. Finally, based on a study conducted by META Systems, Inc. (1985), we present the META staff estimates of the benefits from improved water quality in Boston Harbor. To set the stage for reviewing their estimates, we give a general overview of the water pollution problems in the Harbor, discussing the known sources of pollution and the new facilities designed to control pollution from those sources. The new pollution control facilities are expected to improve the water quality of the Harbor and lead to an increase in benefits to users and nonusers of the Harbor environment.

Benefit Measurement Techniques

The theory of consumer surplus provides analysts with the conceptual basis for defining and estimating the benefits from improved water quality. In Figure 1, we show two demand curves for a given recreation site with water-quality improvements (CD) and without water-quality improvements (AB). The demand function for the curves relates the quantity of recreation use demanded by a user, to the user's participation cost, while holding constant other important determinants of demand, such as water quality, congestion, income, travel time, and availability of substitutes (Greenley, 1982, p. 9).

Given initial levels of pollution at the specified site and an average price P_1, users will demand quantity Q_1. The value of recreation at this site under initial conditions is defined as consumer surplus, which is measured by the area AFP_1. With improvements in water quality, demand increases to Q_2 as the demand curve shifts out and to the right. The value of recreation at the site as a result of the improvement in water quality is the new level of consumer surplus, the area CGP_1. The economic benefit of improved water quality is then measured by the increase in the user's willingness to pay (measured along the Y-axis); this is the area CAFG.

Economists divide this area, the increase in consumer

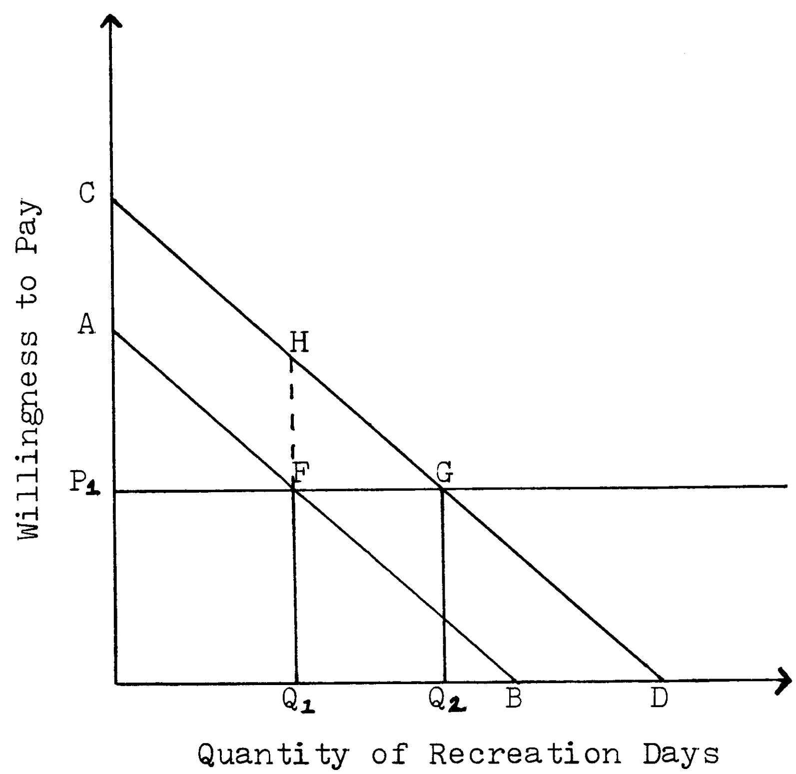

Figure 1

Change in Quantity Demanded With
Improved Water Quality at Specified Site

Note: P_1 denotes Price.

surplus, into two components: the benefit to current users (area AFHC); and the benefit associated with increased use of the site by both current users and new users (area FGH). Economists use these two components of consumer surplus to estimate the benefits from improved water quality: the increased price that consumers are willing to pay for a given level of improvement; and increased participation at the site as a result of the improved water quality. Among the methods available to analysts for measuring these components of consumer surplus, two of the more commonly used approaches are the travel cost approach and the contingent valuation approach (Smith, 1986; Greenley, 1982).

The travel cost approach, specifically, the conditional, multinomial logit, travel cost demand model, allows analysts to describe the probability that an individual will choose to visit each of a subset of recreation sites given that the individual takes a trip to any site. This probability is conditional on the total number of visits that the individual takes and is a function of distance to the site, socioeconomic factors, and water-quality variables. This model allows analysts to simulate changes in use at all recreation sites as the level of water quality at one or more sites is altered. From these simulated changes, analysts can infer the recreational value of the change in water quality (Caulkins, et al., 1988, p. 1278).

Based on the results of the model, analysts can then construct a set of demand curves for each site to represent recreation demand before and after water quality improves. The area between the set of curves at each site (the demand curve shifts upward and to the right to reflect the increase in demand) represents the economic benefits of the water-quality improvement to the individuals visiting the site. Although this method relies on actual improvements in the water quality at study sites, Feenberg and Mills (1980, p. 169) point out that this model "...is the best technique available to cope with problems that arise from the interdependent nature of visits to a variety of water-based recreational sites..., and it leads naturally to precise benefit measurement."

The second approach, the contingent valuation approach, allows analysts to estimate benefits under hypothetical prospective situations and thus, "is not confined to observed behavior" (Greenley, 1982, p. 12). Because the method requires that analysts question users of recreation sites, it directly measures users' willingness to pay contingent on hypothetical changes in water quality. A regression coefficient based on the stated values provides analysts with a statistical estimate of the shift in willingness to pay with changes in water quality, while holding constant all other determinants of demand. Doubts about the accuracy of this survey-based method is a major disadvantage of the contingent valuation approach. In using this approach, analysts assume that individuals do not behave strategically, do not give haphazard responses, and are not influenced by the interviewer or questionnaire (Smith and Desvousges, 1986, p. 35). A significant advantage of this approach, however, is that it allows analysts to value both nonuser benefits and specific types of recreation activities, such as fishing, swimming, and boating.

These concepts and methods for estimating the benefits from improved water quality form the basis for analysts in metropolitan Boston to measure the benefits of water pollution control in Boston Harbor. Current demand for recreational use of the Harbor is compromised by high levels of wastewater pollution. Although environmental policies mandate improvements in water quality, analysts must still determine the value of these improvements to users and nonusers of the Harbor. The following describes current pollution conditions in the Harbor, the plans to reduce the levels of pollution, and the estimated benefits of the improvements in water quality.

Water Pollution in the Boston Harbor

Wastewater from 43 cities and towns in the metropolitan area, a total population of nearly 3.7 million people, enters Boston Harbor from the following sources: 1) Deer Island and Nut Island sewage treatment plants; 2) combined sewer overflows pipes (CSOs) and Quincy storm sewers; 3) sewage sludge; and 4) direct industrial discharges. The major contributors of wastewater to the Harbor are the sewage treatment plants and the CSOs and Quincy storm sewers. More than 450 million gallons per day (mgd) of primary treated sewage[3] are discharged into Boston Harbor from the Deer Island and Nut Island sewage treatment plants. This flow is between one-half and three-quarters of the combined average flow of the Charles River, Mystic River, and Neponset River, all of which empty into the Harbor (Division of Marine Fisheries, 1985, p. 7).

The system of combined sewer overflow (CSOs) pipes located along the Harbor shoreline and along the Charles, Mystic, and Neponset Rivers empties an estimated 5 to 10 billion gallons per year of untreated overflow into Boston Harbor (MWRA, 1988, p. 8). CSOs are combined sewers in the Greater Boston area that collect both stormwater runoff and raw sewage in a single pipe. During heavy rainfalls, the flow of stormwater combined with raw sewage exceeds the capacity of the interceptor pipes that carry this combined flow to the sewage treatment plants. When this occurs, the untreated overflow is emptied directly into Boston Harbor and its tributaries. Dry-weather CSOs occur continually and are also a significant source of pollution to the Harbor. They result from insufficient sewer

[3]According to the MWRA (1989), primary treatment is wastewater treatment afforded by sedimentation. It results in the removal of 50-60% of suspended solids and 30-34% removal of biodegradable, oxygen-demanding contaminants in wastewater.

capacity and malfunctions of flow regulator mechanisms.

The Quincy storm sewers are a separate system of pipes that carry only stormwater runoff from roofs, streets, and parking lots during a storm (MWRA, 1989). Even though storm sewers are not designed to conduct wastewater, the Quincy storm sewers are a significant source of pollution because they contain higher levels of sewage and other contaminants than are expected from stormwater runoff.

Although all of the sources we listed above are responsible for the high levels of pollution in Boston Harbor, effluent from the Deer Island and Nut Island plants and discharges from CSOs have the greatest environmental impact on Boston Harbor (Caulkins, et al., 1988, p. 1275). The geographic location of the treatment plants and the CSOs within the Harbor results in differential impacts on the receiving waters and, consequently, on the activities that occur in specific areas of the Harbor (see Figure 2). The Deer Island and Nut Island effluent tends to affect the quality of waters surrounding the plant outfalls in the central and outer Harbor because of its high levels of fecal bacteria and oxygen-demanding chemical and biological contaminants. Consequently, finfishing and recreational use of the more than 14 Boston Harbor Islands are negatively affected.

CSOs tend to affect the quality of the waters closest to the shoreline and the shellfish beds adjacent to the outfalls.

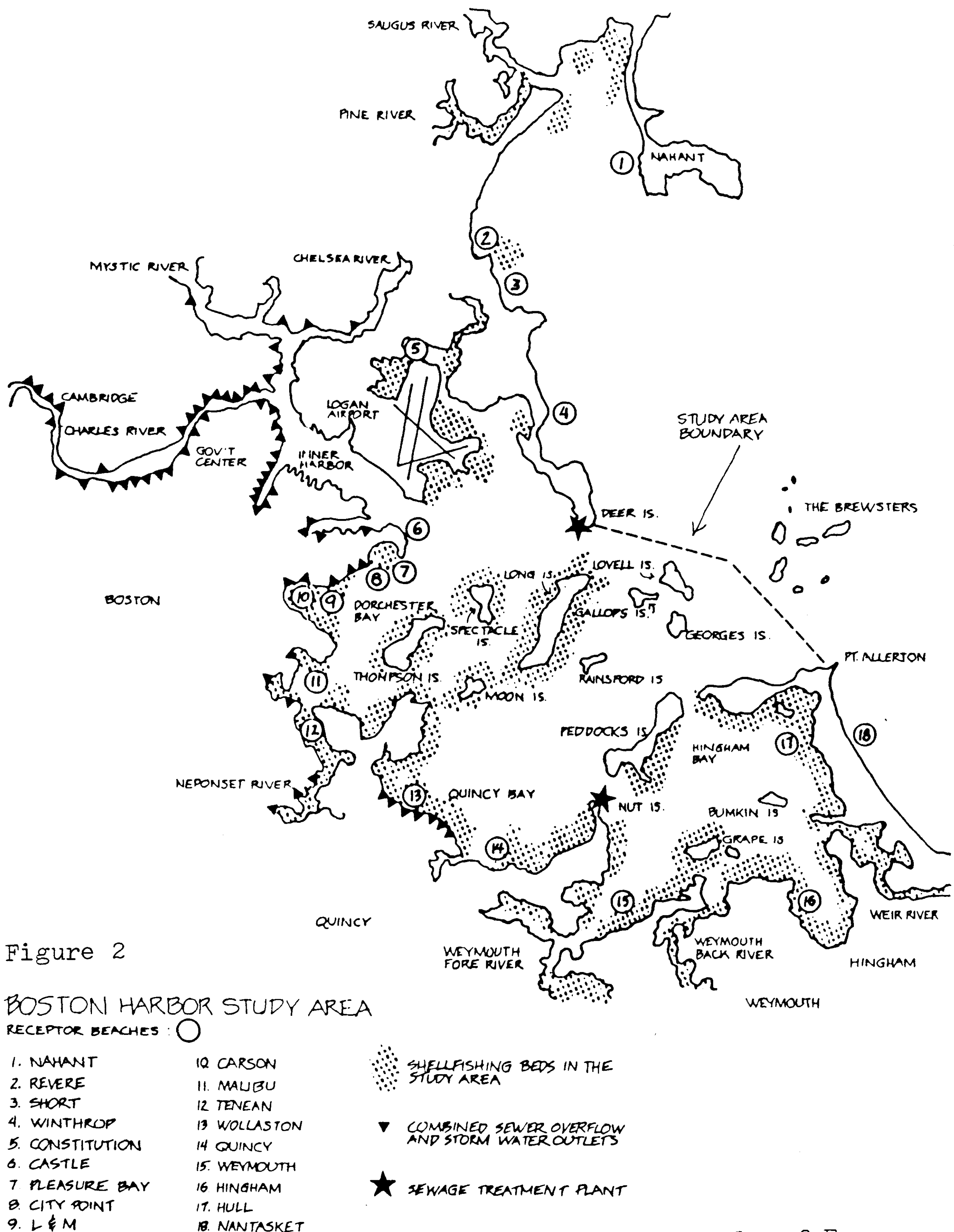

Figure 2

Source: Caulkins, Peter, et al. 1988. "The Role of Economic Benefits Analysis in Funding Marine Combined Sewer Overflow Projects--Case Study of Boston Harbor." Journal of the Water Pollution Control Federation, Vol. 60, pp. 1275-1280.

These overflows, especially those directly after a rainfall, generally contain dangerous levels of fecal matter, toxic chemicals, and road debris. As a result, activities, such as beach swimming, boating, and commercial and recreational shellfishing in Dorchester Bay and Quincy Bay, are adversely affected. Contamination from CSOs are "a major reason why more than half of the productive shellfish beds in the Harbor are classified as grossly contaminated and are closed" (Caulkins, et al., 1988, p. 1276). The Inner Harbor is the most severely affected area of the Harbor because it contains the greatest number of CSO outfalls (see Figure 2) and is used primarily for commercial shipping activity.

The worsening of these environmental conditions and the inaction of public officials in preventing further degradation of the Harbor, led the City of Quincy, in 1982, to file suit against the Metropolitan District Council (MDC), the Boston Water and Sewer Commission, and other state agencies for their pollution of Boston Harbor. The City of Quincy claimed that these agencies had violated the Massachusetts Clean Water Act and the Massachusetts Environmental Policy Act by illegally discharging untreated sewage into Boston Harbor (Haar, 1986, p. ix). After lengthy court proceedings, problems of legal authority and responsibility, and legislative indecision, the Massachusetts Water Resources Authority was created in 1985 to assume responsibility for operating and maintaining the municipal wastewater system. In addition to this responsibility, the MWRA is to "ensure compliance with environmental law, and guarantee quality service to the cities and towns" in the metropolitan region (MWRA, 1989, p. 1).

Thus, MWRA undertook a construction program to upgrade and repair existing wastewater (and waterworks) facilities. The construction program proposed by MWRA includes the following new facilities (MWRA, 1988):

1) a sewage treatment plant at Deer Island to provide improved primary treatment by 1995 and complete secondary treatment by 1999;
2) a nine-mile, 28-foot diameter outfall tunnel to convey treated wastewater to Massachusetts Bay by 1995;
3) a sludge processing plant to recycle sewage sludge by 1999; and
4) repair of the combined sewer overflow system by 1999.

Additional construction will upgrade existing sewage collection and pumping facilities, which are between 50 and 85 years old and can no longer handle current sewage flows.

Benefits Estimates for Boston Harbor

The META study (1985) provides estimates of the gross benefits to Greater Boston from water-quality improvements resulting from these facilities. As stated by META staff, the purpose of the study "is to determine the feasibility and the usefulness of an economic analysis of the beneficial outcomes resulting from upgrading sewage treatment plants and from combined sewer overflow control" (META, 1985, p. 1-1). Thus, META staff focus their analysis on two pollution control alternatives that were under consideration by MWRA at the time of their 1985 study. These alternatives would have the greatest environmental impact on the Harbor. They are:

1) control of pollution due to CSOs and storm water discharges, and
2) upgrading existing primary treatment with a secondary treatment facility and adding an ocean outfall tunnel.

Although MWRA has not yet included in its current capital budget the expenditures for complete CSO repair, we understand that the entire project is scheduled for completion by 1999. Thus, our analysis will include the estimated benefits from complete CSO repairs rather than from the partial plans currently being developed by MWRA.

Recreation benefits represent the largest source of measurable benefits resulting from these pollution control alternatives and accrue to swimmers, boaters, anglers, and others who use the beaches and the Boston Harbor Islands. These benefits are especially important for the urban area of Boston given the City's growing population and the increasing attraction to its coastal areas due to their resources, aesthetics, and recreational opportunities. META staff point out that two major components of consumer surplus fully capture these recreation benefits: 1) increase in participation, and 2) increase in the price participants are willing to pay per visit for the improved recreational experience. To measure total consumer surplus, META analysts use a range of user-day values as a proxy for individual consumer surplus. The number of additional user participation days times the user-day value for each type of recreation activity gives an estimate of the value of the increase in consumer surplus. META staff indicate that, although the user-day value is the best available proxy for individual consumer surplus, it does not capture the entire consumer surplus because it cannot measure increased enjoyment per visit due to improvements in water quality.

META analysts employ the following estimation methodologies to estimate benefits related to increased recreational use for each type of activity (swimming, boating, recreational fishing, and Harbor Islands) in Boston Harbor:

1) recreation studies to predict and value increases in participation;
2) the travel cost, conditional logit model to estimate gains in consumer surplus due to increased participation and increased satisfaction per trip; and
3) calculation of lost consumer surplus due to beach closings.

Of these three methods, META analysts find that the travel cost approach gives the most reliable estimates of the benefits of increased recreation because of "the theoretical and empirical strengths of the logit model." The recreation studies approach suffers disadvantages in that the analysts are unable to measure latent or unmet demand. A measure of latent demand is important given that increased demand is a function of potential demand, which, in turn, is constrained by the capacity of the recreation site and the demand for the resource. Lack of sufficient data also limits the reliability of recreation studies. Benefit estimation based on calculations of lost consumer surplus is problematic because the analysts must measure lost participation based on average seasonal beach attendance; therefore, their estimates do not capture the significant beach attendance that occurs before and after the peak swimming seasons (Memorial Day and Labor Day).

META staff provide estimates of other benefits from water-quality improvements, such as health, commercial fishing, and intrinsic (or preservation) value. Health benefits accrue to users of Boston Harbor from reduction in swimming-related illness and illness related to bacterial contamination of shellfish. They are measured by the willingness to pay to avoid illnesses. META analysts base the valuation of these illnesses on national studies of swimming-related illnesses.

Commercial fishing benefits accrue from increased shellfish, lobster, and finfish productivity; however, lack of necessary data on where fish are caught and how they might be affected by improved water quality prevents a benefit valuation for finfishing and lobstering (the most valuable fishing conducted within Massachusetts waters). Better data availability allows them to make a more detailed benefit valuation for commercial shellfishing.

Intrinsic benefits (or preservation value), as defined in the META study, are all benefits associated with a resource that are not specifically related to current, direct use of the resource. They include:

1) option value--the willingness to pay to insure access to a resource or to endow future generations with the resource (bequest value);
2) aesthetic value--the enhanced appreciation of water-related experiences; and
3) existence value--the willingness to pay for the knowledge that the resource is available and is being protected.

Ideally, willingness to pay would most accurately measure intrinsic value; however, because intrinsic benefits are difficult to measure and value, and no specific studies applicable to the entire Boston Harbor or to the pollution control options were available, META analysts valued these benefits based on one-half the benefit estimates for recreation.

In addition to these benefits, ecological processes within Boston Harbor will improve due to reductions in pollutants and toxic contaminants. META staff had difficulty quantifying the ecological changes that might take place as a result of improved water quality; therefore, they made a qualitative assessment of the benefits in this category. We present the META estimates (in 1982 dollars) of the benefits from improved water quality in Table 1. These are gross, and not net, benefits. They are simply the benefits that will accrue directly to those who use the Harbor once water quality is improved. The economic cost, in terms of resources that are drawn from other alternative productive uses, have not been taken into account.

The estimates presented by META analysts are meant to be neither precise nor inherently significant. They are approximations developed from conservative assumptions and, in general, understate the benefit values of the various pollution control alternatives. Some major limitations of the analysis are related to inaccurate and insufficient data. For the case of recreational participation, META staff base attendance figures, beach capacity, and latent demand on professional estimates or "best guesses", rather than on survey data. For the case of nonrecreation benefits, sufficient data are unavailable for measuring variables such as: (1) the location of lobster and finfish harvests; (2) the relationship between pollution and shellfish consumption; (3) the willingness to pay of nonusers under specific water-quality conditions; and (4) the connection between levels of pollution control, the subsequent reduction of pollutant levels, and the functioning of ecosystems in the Harbor.

Table 1

Incremental Annual Benefits
(thousands of 1982 dollars)

Benefit Category	Estimated Increase	
	Lower Bound	Upper Bound
Recreation		
Swimming	$18,000	$19,000
Fishing	12,000	15,000
Boating	12,000	15,000
Harbor Islands	1,000	3,000
Commercial Fishing	60	--
Health	1,500	--
Intrinsic	16,000	17,000
Ecological	--	--

Source: META Systems, Inc. 1985. "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements from Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls." Prepared for the Office of Policy Analysis, Environmental Protection Agency, Washington, D.C. p. 1-24.

Furthermore, META analysts base estimates of increased recreational participation on results from national and regional water-quality benefit studies. These studies may provide inaccurate estimates for the Boston area because metropolitan Boston is larger than the average metropolitan area, and it is colder than most of the country, making clean water less valuable for recreation than it would be in warmer areas. In pointing out these considerations, however, Feenberg and Mills conclude that in their judgement, "these two considerations nearly offset each other..." (Feenberg and Mills, 1980; p. 164).

In spite of the limitations and shortcomings of their study, META staff estimate that the benefits from improved water quality are fairly useful. Not only do they emphasize the significance of the benefits from water quality improvements, but they also dramatize the need for reliable data that would allow more accurate and complete determination of these benefits. For the case of our research, the META estimates provide a range of values from which we can determine the economic repercussions resulting from improvements in the water quality of Boston Harbor.

Chapter 3

BOSTON FORECASTING AND SIMULATION MODEL

In this chapter, we describe the modeling technique we use in assessing the impact of the Boston Harbor cleanup. We first provide a general overview of economic impact methodologies and then characterize the specific microcomputer model we used to conduct our analysis. Following this, we represent the construction expenditures for the cleanup and the benefits of improved water quality as policy alternatives that will be introduced into the impact model.

Economic Impact Models

Regional analysts use three modeling techniques to measure economic impacts: economic base models, macroeconometric models, and input-output models. These models vary in terms of the detailed information they present, the data and effort they require, and the causes of regional growth (Pleeter, 1977, p. 8). Economic base analysts divide regional economic activity into two distinct sectors: an export-serving ("basic") sector, which produces goods and services to be sold outside the region; and a local-serving ("nonbasic") sector, which produces goods and services for local consumption (Sivitanidou and Polenske, 1988, p. 101). They assume that regional trade is the primary impetus for growth and ignore internal growth stimuli, such as local government expenditures, changes in productivity, technological change, and population increases. Thus, the economic base model is more appropriate for analysts assessing regional impacts in small regional economies, where exports represent a larger proportion of total regional activity, and where the policy impact is of relatively short duration--less than one year (Pleeter, 1977, p. 12).

In macroeconometric models, analysts use multiple-equation systems that represent structural relationships within regional economies. These models employ time-series data and regression analysis to estimate the economic effects of external changes in variables, such as output, income, and employment. Their use of time-series data allows analysts to examine underlying trends, thus making macroeconometric models more appropriate for analysts assessing longer-run problems--five or more years (Pleeter, 1977, p. 22). Although macroeconometric models, in general, emphasize external causes of regional growth, more sophisticated models consider both internal and external sources of regional growth.

Finally, input-output models provide detailed information about the inter-industry transactions that take place within a local economy. In these models, analysts divide sales by firms into sales to intermediate users and sales to final users. The assumptions are that technology requirements for each sector are constant for periods of 5 to 15 years, inputs are used in fixed proportions, wages and prices are constant, and no economies or diseconomies of scale exist. These assumptions make input-output models appropriate for analysts assessing short-run economic impacts. Input-output relationships must be revised over time as technological change and input substitution, for instance, take place.

Although each of these modeling techniques has desireable features, their use depends on the nature of the regional problem and the availability of resources. Many computer programs exist, which combine some of the features of these three modeling techniques. One such program is the REMI Model. REMI is a regional macroeconometric model for forecasting and simulating the aggregate economic behavior of subnational economies, usually states (Sivitanidou and Polenske, 1988, p. 103). It uses two models for simulating policy changes: an input-output model, which provides details about inter-industry economic transactions; and a fiscal-simulation macroeconometric model, which allows long-run determination of economic impacts. It may also be used for economic base analysis.

This model allows analysts to estimate more accurately, and more completely, than with other regional models the economic impact of policy changes that occur over relatively long periods of time. A significant drawback of REMI, however, is that it is region-specific and requires an enormous amount of detailed information, which must be purchased as part of the package. Thus, analysts cannot apply

REMI easily to another subregional economy.

In terms of the data base for REMI, the fiscal simulation model contained in the program was initially calibrated to be consistent with the forecasts of the United States Bureau of Labor Statistics (Sivitanidou and Polenske, 1988, p. 103). The historical data base goes from 1969 to 1986, and forecasts go from 1987 to 2035. Data on employment, wages, personal income and prices are derived from other data sources, such as the Bureau of Economic Analysis, the Bureau of the Census, and County Business Patterns. In what follows, we describe the way in which the model operates. We base our description on the REMI documentation (Treyz, et al., 1986).

REMI provides more than 802 policy variables for simulating and forecasting policy changes. Most of these variables can be assigned to general categories by the type of changes they represent and by the way they affect the model. The policy variables are divided into two groups based on whether they directly or indirectly affect the model: regular policy variables and special translator policy variables, respectively. Regular policy variables directly change specific economic variables, such as employment, wages, investment, sales, and demand. Special translator policy variables represent a broad range of economic activity that is translated to the model through a combination of regular policy variables. The following example illustrates the distinction between these two groups of policy variables.

If regional analysts want to measure the impact of an increase in tourism resulting from the opening of a new amusement park, they may enter the increase in tourism in two alternative ways. If they have specific estimates of purchases by tourists, they may use the regular policy variables that represent increased spending in an area (DEMPOL) and an exogenous change in the sales of locally produced goods (SALPOL). Otherwise, they may use the special translator policy variable for tourism and enter the increase as a change in the number of tourist visitor days per year. The model translates the increase in the number of visitor days into the number of tourist dollars spent across a number of specific sectors, such as hotels, eating and drinking places, and personal services.

These regular and translator policy variables affect the model by one of five methods:

1) directly changing the level of economic activity in an industry (examples are direct employment effects, dollar output, agriculture and construction output, and changes in tourism).
2) changing the production costs (examples are energy costs, business taxes, transportation costs, a change in the wage rate, unemployment insurance, and the general cost of doing business).
3) changing final demands (examples are government demand, income taxes, personal income, investment,

and consumption demand).

4) changing labor supply and population (an example is migrant influx, which would increase the general population).

5) changing other variables defined by the user (this is any policy change that can be translated into a change in one of the model equations).

Policy simulations that are based on the policy variables and their methods of operation fall into eight general categories. They are:

1) Tourism--entered as a change in the number of visitor days, a change in consumption, a change in sales, or a change in employment.

2) Development--entered as a change in the dollar amount of construction, investment, agricultural production, sales, or demand; also entered as a change in the level of employment.

3) Transportation--entered as the percent change in total transportation costs due to a change in import transportation, export transportation, and in-state transportation; also entered as a change in the dollar amount of road and rail construction, trucking costs, and transportation services.

4) Environment--entered as a change in construction activity, production costs, population, and employment.

5) Energy and Natural Resources--entered as a change in energy costs, residential oil fuel costs, construction, and consumer fuel costs.

6) Taxation, Budget, and Welfare--entered as a change in corporate profit tax rate, equipment investment credit, equipment and property tax rate, personal taxes, and transfer payments.

7) Labor and Occupational Training--entered as changes in labor demand, occupational labor supply, population, unemployment compensation tax rate, wage rate, and wage bill.

8) Private Sector Uses--entered as changes, by individual firms, in construction, employment, energy fuel cost, new output, and investment.

Regional analysts in Massachusetts have access to the REMI Model for the state as well as for the Boston Metropolitan area. The Boston Metro Two-Area FS-53 Forecasting and Simulation Model (Boston Model) is the Boston-specific version of the REMI Model. It is a substate, multi-area version of the Massachusetts Model that produces comprehensive economic forecasts for Suffolk County and the rest of the Boston metropolitan region. The model accounts for the interaction of these two areas; for example, a policy change in Suffolk County would affect the Rest of Metro Boston, and these effects would, in turn, affect Suffolk County. We use this model to simulate the economic impact of the Boston Harbor cleanup.

We use two kinds of simulations to represent the cleanup process. First, we use Environment to represent the construction of new conservation and environmental protection facilities. We enter the change in the dollar amount of construction through the construction translator policy variable for New Conservation and Other Development Facilities. Second, we use Tourism to represent the change in the number of tourist visitor days generated as a result of improved water quality. We enter the increase in visitor days through tourism translator policy variables for specific types of tourism. We discuss how we use the proposed construction expenditures and the estimates of recreation benefits in the Boston Model.

Modeling the Construction Investments

Proposed expenditures for the Boston Harbor cleanup make it the largest public works project of its kind to occur in the United States. If the proposed budget is approved, MWRA will spend approximately $6 billion (in current dollars) by 1999 to improve the water quality of Boston Harbor. In comparison to their other capital improvement programs, expenditures on wastewater improvements represent more than 80% of total capital improvement expenditures. The other programs include, waterworks improvements, administrative and support facilities improvements, and contingency.[4] Table 2 shows the expected annual cost of wastewater construction relative to the other capital improvements proposed by MWRA, from 1990 to 1994 and beyond. Wastewater expenditures, in general, comprise an increasingly larger percentage of total expenditures for capital improvements thus, illustrating the magnitude of the policy mandate. They are expected to be 71% of the total Fiscal Year 1990 Capital Improvement Program (CIP), 93% of the Fiscal Year 1994 budget, and 98% of total capital improvement spending beyond Fiscal Year 1994.

The wastewater component of the capital improvement program can be broken down into the individual projects in Table 3. The proposed annual expenditures on these projects are given in 1990 dollars. Because the proposed expenditures beyond 1994 are provided only as a total (from Table 2), we distributed this estimate, nonlinearly, through the year 1999. Given that cumulative expenditures for large construction projects typically follow an S-shaped pattern, we distributed the proposed expenditures for beyond 1994 as shown in Table 4 (we rounded numbers to the nearest $100 thousand given that

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[4]Contingency are certain costs associated with the Capital Improvement Program (CIP) that are not possible to predict with any degree of certainty. These costs include legal fees, settlement of claims, acquisition of land and a variety of study, design and construction change orders and contract amendments (CIP, 1989, p. 258).

Table 2

Massachusetts Water Resources Authority
Proposed Capital Improvement Program:
Fiscal Years 1990-1994 and Beyond
(millions of 1990 dollars)

	Fiscal Year					
Program	1990	1991	1992	1993	1994	Beyond 1994
Wastewater	316.6	255.1	429.2	578.7	592.2	1,061.7
% of Total	77%	71%	78%	88%	93%	98%
Waterworks	42.7	34.5	45.8	33.1	12.9	18.0
% of Total	10%	9.5%	8.3%	5.0%	2.0%	1.7%
Adminis-tration	34.8	34.4	10.2	0.5	0.4	0.9
% of Total	8.5%	9.6%	1.9%	<.1%	<.1%	<.1%
Contingency	16.6	34.3	65.3	48.7	31.0	0.0
% of Total	4.0%	9.6%	12%	7.4%	4.9%	0%
Total	410.7	358.3	550.5	661.0	636.4	1,080.6

Source: Massachusetts Water Resources Authority. 1989. **Proposed Capital Improvement Program, Fiscal Year 1990 to 1992.** Boston, Massachusetts: MWRA, p. 6.

Table 3

Wastewater Improvement Program and Capital Expenditure Budget: Fiscal Years 1990-1992
(thousands of 1990 dollars)

Program Category	Fiscal Year 1990	1991	1992	Beyond 1992
Interception and Pumping	62,975	47,116	59,046	58,747
Treatment	209,804	160,958	287,406	1,696,502
Residuals	34,566	44,595	82,759	477,265
CSOs	8,904	2,437	0.0	0.0
Other Projects	339	0.0	0.0	0.0
Retainage	37	0.0	0.0	0.0
Total	316,625	255,106	429,211	2,232,514

Source: Massachusetts Water Resources Authority. 1989. **Proposed Capital Improvement Program, Fiscal Year 1990 to 1992.** Boston, Massachusetts: MWRA, p. 19.

Table 4

Anticipated Expenditures on Sewerage Construction for Fiscal Years 1987-1999
(thousands of 1990 dollars)

Year	Project Cost	Cumulative Cost
1987	$ 62,600	$ 62,600
1988	165,900	228,500
1989	225,000	453,500
1990	316,600	770,100
1991	255,100	1,025,200
1992	429,200	1,454,400
1993	578,700	2,033,100
1994	592,200	2,625,300
1995	361,707	2,987,000
1996	200,000	3,187,000
1997	200,000	3,387,000
1998	200,000	3,587,000
1999	100,000	3,687,000

Note: Expenditures for Fiscal Years 1987 and 1988 represent actual expenditures.

Source: Author's calculations based on data presented in Massachusetts Water Resources Authority. 1989. **Proposed Capital Improvement Program, Fiscal Year 1990 to 1992.** Boston, Massachusetts: MWRA, p. 19.

they are rough estimates of proposed spending).[5] A plot of the cumulative construction expenditures over the 11-year construction period is shown in Figure 3. We can see that construction expenditures increase steadily from 1987 to 1991, and become much steeper between 1991 and 1994. After 1994, they begin to rise at a slower rate, and then start to level off by the end of the construction period.

For the simulation, we entered the construction expenditures into the Model in 1977 dollars.[6] Thus, we deflated the MWRA estimates (given in 1990 dollars) to their 1977 equivalents. The following represents our understanding of how MWRA arrived at their 1990 estimates; it is based on information provided in the MWRA CIP (1989) for fiscal years 1990 to 1992 and on conversations with staff members. MWRA adjusted all current construction contracts (those currently in operation) that were estimated in fiscal year 1988 (in 1988 dollars) to fiscal year 1990 dollars using an inflation rate of 6%. They estimated, in 1990 dollars, all project phases scheduled to begin after 1992. Based on these adjustments, we deflated all annual expenditure estimates, except the 1987 and 1988 estimates, to 1988 dollars using an inflation rate of 6%. Then, we used the Producer Price Index (PPI) for materials and

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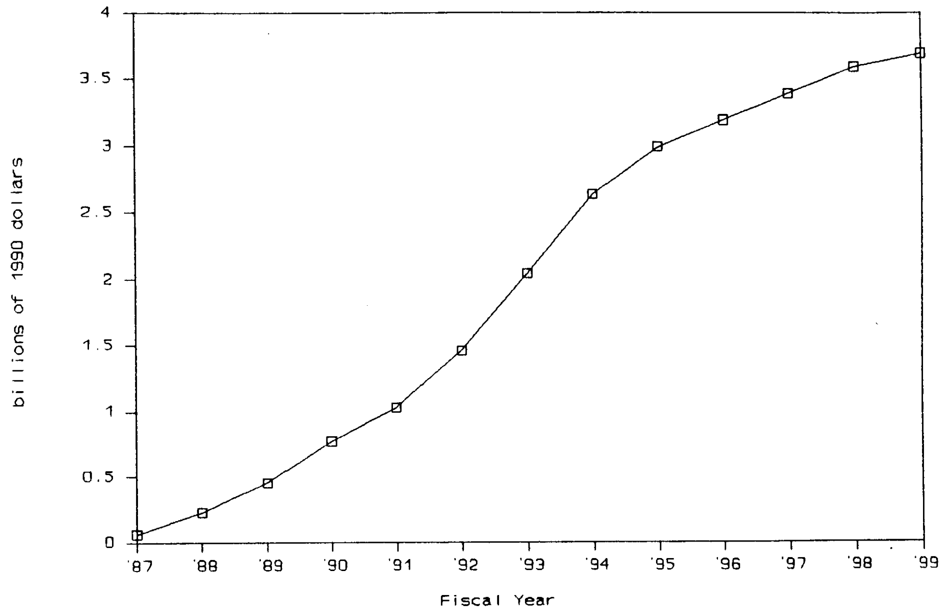
[5]We distributed the estimates for construction beyond 1994 according to the advice of Richard Tabors.

[6]The REMI Model requires either 1977 dollars or nominal dollars, which it converts into 1977 dollars based on the Consumer Price Index (CPI).



Source: MWRA. 1989. Capital Improvement Program: Fiscal Year 1990-1992. Boston, Ma.

Figure 3

MWRA CONSTRUCTION EXPENDITURES, 1987 - 1999

components for construction (Economic Report of the President, 1988, p. 320) to deflate these revised estimates (in 1988 dollars) to 1977 dollars.[7] Given that the actual value of the PPI for 1988 is not yet available from the Bureau of Labor Statistics, we made a simple projection that the index would

[7]We would have preferred to use the Handy-Whitman Index of Public Utility Construction Costs; however, it was not available in the Boston academic community.

grow by 1.5% by 1988. In Table 5, we show the revised construction expenditures in 1977 dollars.

We entered these expenditures into the Boston Model through the construction translator policy variable for New Conservation and Other Development Facilities. This policy variable calculates, for each new dollar of output in construction, how much of that dollar must be spent on inputs from every other sector. This is the first round of indirect effects in input-output terms. Given that construction takes place in Suffolk County, we entered the construction expenditures as a policy change affecting the Suffolk County portion of the two-sector Boston Model.

Because investment in new construction is generally considered to be transitory by nature, we believe that construction of the new facilities will have no long-term effects on wage rates, although wages will, in general, respond to the increased demand stimulated by the construction activity. Also, because the construction employment is added exogenously, the resulting increase in the level of investment is only a short-term change. Based on these assumptions, we suppressed the model´s normal endogenous wage and nonresidential investment responses to the exogenous employment represented by the new construction investments. We turn, now, to describing how we entered the benefit estimates into the Boston Model.

Table 5

Anticipated Expenditures on Sewerage Construction for Fiscal Years 1987-1999
(thousands of 1977 dollars)

Year	Project Cost
1987	$ 39,547
1988	103,100
1989	131,900
1990	185,600
1991	149,600
1992	251,600
1993	339,200
1994	347,200
1995	212,000
1996	117,300
1997	117,300
1998	117,300
1999	58,600

Source: Author's calculations based on Table 4, MWRA inflation adjustments, and deflation using the Producer Price Index.

Modeling the Recreation Benefits

In Chapter 2, we presented the META estimates of the benefits from the pollution control projects. We show these estimates again in Table 6. Of the total annual increase of $61 to $69 million (in 1982 dollars), recreation benefits are largest. They represent 75% of all water-related benefits measured by META staff. Thus, the primary effect of the pollution control facilities is to increase recreation activity in Greater Boston. For the simulation, we used tourism as a proxy for increased recreation activity. This is because recreationists who visit the Harbor act like tourists in terms of their purchases of goods and services, and recreationists will include tourists and vacationers from outside the metropolitan area.

We used the tourism translator policy variables in the Boston Model to simulate the increase in recreation. These policy variables require either estimates of specific purchases by tourists or specific estimates of the increase in tourist visitor days. We started with estimates of increased tourist visitor days given that we did not have estimates of specific purchases by tourists. Based on the results of tourist expenditure research, the Boston Model translates the increase in tourist visitor days into an increase in the amount of tourist dollars spent across specific industrial

Table 6

Incremental Annual Benefits
(thousands of 1982 dollars)

Benefit Category	Estimated Increase	
	Lower Bound	Upper Bound
Recreation		
Swimming	$18,000	$19,000
Fishing	12,000	15,000
Boating	12,000	15,000
Harbor Islands	1,000	3,000
Commercial Fishing	60	--
Health	1,500	--
Intrinsic	16,000	17,000
Ecological	--	--
Total	60,560	69,000

Source: META Systems, Inc. 1985. "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements from Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls." Prepared for the Office of Policy Analysis, Environmental Protection Agency, Washington, D.C. p. 1-24.

sectors. In Table 7, we show, for each type of recreation activity, estimates of the annual increase in visitor days due to improved water quality. Before we continue, we should explain from where we got these specific visitor day estimates.

With the exception of the estimates for the Boston Harbor Islands, we had to compute the estimates in Table 7 by using more detailed monetary benefit estimates and estimates of approximate user-day values[8] made by META analysts. We summarize these data in Table 8. META analysts did not provide, consistently, the specific estimates of visitor day increases for each recreation activity. In most cases, they provided only a range of estimates for combinations of pollution control alternatives; therefore, we used their data (Table 8) to derive the specific visitor day estimates. We divided the monetary benefit estimates (in 1982 dollars) by the approximate user-day value to get the visitor day increase. In Table 8, column A shows high and low estimates of the approximate user-day value for each activity and column B (except for the numbers in parentheses) shows the monetary value of the increase in user participation resulting from different pollution control options. The numbers in parentheses represent our estimates of the change in visitor days and are the result of dividing numbers in column B by the

[8]The user-day value measures the user´s willingness to pay for each recreation experience.

Table 7

Annual Increase in Visitor Days
(thousands of visitor days)

	Estimates	
Benefit Category	Lower Bound	Upper Bound
Swimming	1,832	2,915
Boating	445	445
Fishing	65	348
Harbor Islands	322	478
Total	2,664	4,186

Source: META Systems, Inc. 1985. "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements from Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls." p. 6-60. Prepared for the Office of Policy Analysis, Environmental Protection Agency, Washington, D.C.

Table 8

Change in Annual Recreation Benefits
(thousands of 1982 dollars)

COLUMN A		COLUMN B					COLUMN C
		Pollution Control Options					
		(1)	(2)	(3)	(4)	(5)	
Category	Approximate User-Day Value	CSO	Ocean Outfall	Secondary Treatment	1 + 2	1 + 3	Total Change in Visitor Days (thousands of days)
Swimming							
High Estimate	$11.06	17302	1479	1479	--	--	
(Visitor days in thousands)		(1564)	(134)	(134)	--	--	1832
Low Estimate	$5.80	14439	1235	1235	--	--	
(Visitor days in thousands)		(2489)	(213)	(213)	--	--	2915
Boating							
High Estimate	$40.89	--	--	--	12129	14569	
(Visitor days in thousands)		--	--	--	(297)	(356)	445
Low Estimate	$18.14	--	--	--	5386	6463	
(Visitor days in thousands)		--	--	--	(297)	(356)	445
Fishing							
High Estimate	$34.08	--	--	--	7911	9493	
(Visitor days in thousands)		--	--	--	(232)	(279)	348
Low Estimate	$12.89	--	--	--	299	749	
(Visitor days in thousands)		--	--	--	(23)	(58)	65

Table 8 (Continued)

Change in Annual Recreation Benefits
(thousands of 1982 dollars)

COLUMN A		COLUMN B					COLUMN C
		Pollution Control Options					
		(1)	(2)	(3)	(4)	(5)	
Category	Approximate User-Day Value	CSO	Ocean Outfall	Secondary Treatment	1 + 2	1 + 3	Total Change in Visitor Days (thousands of days)
Harbor Islands							
High Estimate	$11.06	--	--	--	--	--	
(Visitor days in thousands)		--	(257)	(221)	--	--	478
Low Estimate	$5.60	--	--	--	--	--	
(Visitor days in thousands)		--	(143)	(179)	--	--	322

Note: CSO denotes combined sewer overflow.

Given that META staff estimated visitor days independent of the user-day value, we do not deflate the monetary estimates to 1977 dollars.

We divided all monetary benefit estimates by user-day values to derive the the increase in visitor days.

Source: META Systems, Inc. 1985. "Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements From Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls." Prepared for the Office of Policy Analysis, Environmental Protection Agency, Washington, D.C. p. 6-60.

corresponding number in column A.

META staff calculated swimming benefits for each individual pollution control option (columns 1, 2, and 3). Of the three options, the CSO option provides the largest benefits given that CSOs have the greatest effect swimming. They calculated fishing and boating benefits for the entire Harbor because these activities occur throughout the Harbor; thus, they estimate benefits for two combinations of pollution control options that represent the entire Harbor area. One is CSO control plus ocean outfall (column 4) and the other is CSO control plus secondary treatment (column 5). Most of the increased participation for fishing and boating comes from the CSO plus secondary treatment option because fishing and boating occur primarily in waters surrounding the sewage treatment plants and, to a lesser extent, in waters close to the shoreline. For the CSO plus ocean outfall option, in particular, most of the benefit is related to CSO control; therefore, to reduce the effect of our double counting the CSO option when we computed the total change in user participation, we made the assumption that 30% of the benefits from the CSO plus ocean outfall option represents the benefits related specifically to the ocean outfall. We show in column C, upper and lower bound estimates of the estimated change in visitor days for each recreation activity.

Concerning the nonrecreation benefits, we were unable to assign the estimates for health, intrinsic, and ecological benefits to specific policy variables in the model. For commercial fishing, the lower bound benefit estimate is fairly small in comparison with estimates of recreation benefits; it is .4% of total recreation benefits. Furthermore, because input-output relationships for marine activities in metropolitan Boston are not available, the Boston Model does not provide detailed information for fishing activities alone. It aggregates into one industrial sector the agriculture, forestry, and fishing services industries. These two factors will make it difficult for us to use the Boston Model to assess the effects on commercial fishing industries. Thus, we simulated the benefits of improved water quality using estimates of increased recreation benefits alone. Given that these estimates, in general, under-represent the actual value of improved water quality, we use the upper bound estimates for the simulation. We divided the annual estimates equally among four, of the five types, of tourism represented by the tourism translator policy variables. They are: 1) hotel/motel, 2) rent apartment or summer home, 3) stay with friend or relative, and 4) day tripper. We omitted the "camper" translator policy variable because it is irrelevant to the urban area of Boston. We assigned a total of 1.046 million visitor days per year to each of these four policy variables.

Even though META staff estimated their benefits as equal annual amounts that would, presumably, extend forever, we preferred to see benefit estimates increase as population increased. This would have provided a more accurate representation of reality and would have produced more meaningful results; however, because META estimates were currently the best data available to us, we used them for our analysis. We made a simplifying assumption that these benefits will begin to accrue in the year 2000, following completion of construction in 1999. Given that increased recreation occurs directly in Suffolk County, we entered the benefits of improved water quality to the Suffolk County portion of the Boston Model beginning in the year 2000.

We suppressed the model's endogenous nonresidential investment response given that visitor day policy variables affect the model through a general exogenous employment variable; this avoids double counting of the effect of employment. We did not suppress the model's endogenous wage rate response given that our policy change, the increase in recreational use of the Harbor, is not brief. We make the assumption that the employment represented by the increase in visitor days is long-term and will have time to work its way into wage rates (Treyz, et al., 1986, pp. 218-230). In Chapter five, we analyze the repercussions of both the construction investments and the recreation benefits on the metropolitan economy.

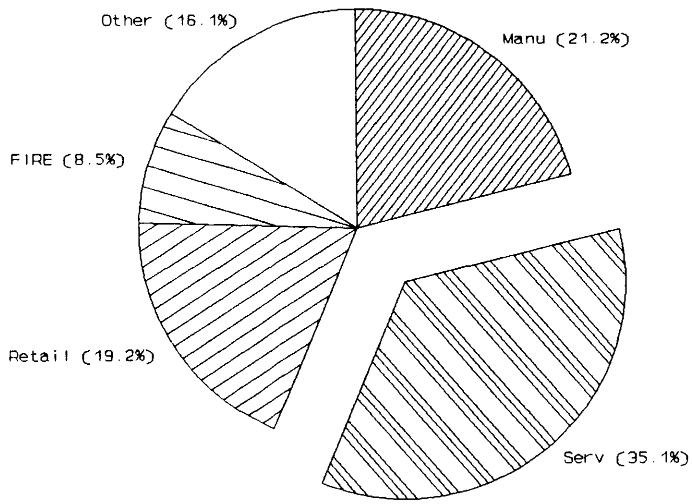
Chapter 4

THE METROPOLITAN BOSTON ECONOMY

Before analyzing the forecasted impacts of the Harbor cleanup, we describe economic conditions in metropolitan Boston based on a historical forecast for 1986 produced by the Boston Model. This forecast is the most recent historical forecast produced by the Boston Model and it provides the high level of economic and sectoral detail we desire for our analysis. We focus on local employment, output, and relative production costs for the services, manufacturing, retail trade, and construction sectors. As of 1986, these are the major employment and output sectors in the metropolitan economy.

In 1986, a total of 3.7 million people lived in the Boston metropolitan area. The local economy employed 1.9 million people in private, nonfarm jobs with nonmanufacturing industries accounting for almost 80% of these jobs. Manufacturing employment, once the major source of employment in the local economy, represented only 21% of total private, nonfarm employment. In Figure 4, we show the relative contribution of manufacturing, services, retail trade, and finance, insurance, and real estate to total private, nonfarm employment. Employment in services industries alone comprised 35% of all private, nonfarm employment.

Decomposition of total private, nonfarm employment by the



Note: See Appendix B for abbreviations.

Source: REMI historical forecast.

Figure 4

RELATIVE CONTRIBUTION TO TOTAL EMPLOYMENT, 1986

source of demand for local industrial output reveals that exports to the United States and the rest of the world created more jobs in the local economy than any other source of demand for local output. Following closely was local consumption demand. Table 9 shows the decomposition of total private, nonfarm employment by local consumption demand, intermediate input demand, export demand, investment activity, and government demand. The data show that:

Table 9

Employment by Source of Demand
(number of employees)

Sector	Demand for Local Output				
	Local Consumption	Intermediate Inputs	Exports	Investment Activity	Government Demand
Manufacturing	21030	58229	277231	14088	14761
Mining	16	232	836	60	2
Retail Trade	277493	41334	10502	5870	20959
Services	211056	111552	241042	117	4117
Contract Construction	9449	7880	3718	35575	2031
Transportation & Public Utilities	15260	24486	39309	1095	-660
Fin., Insur., and Real Estate	52516	33992	29548	623	2998
Wholesale Trade	28420	47516	24003	7804	27443
Agri/For/Fish Svc.	2569	3218	3227	304	-57
Total	617809	328439	629416	65536	71594

Note: Fin., Insur., and Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc. denotes Agriculture, Forestry, and Fishing Services.

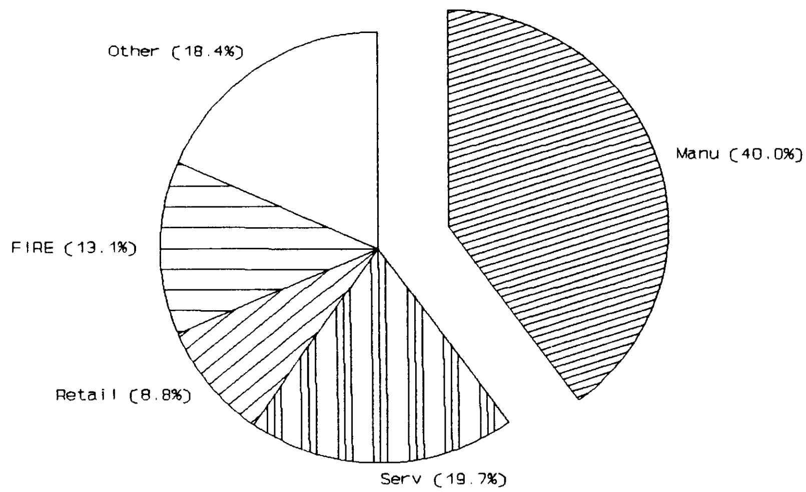
Source: REMI historical forecast.

1) local manufacturing and mining industries relied heavily on exports to markets outside of the local area;
2) employment generation in retail trade establishments relied, overwhelmingly, on local consumption demand;
3) service industries relied on both export demand and local consumption demand to generate employment; and
4) contract construction relied primarily on investment activity to induce employment in construction.

In terms of occupational employment, 17% of all jobs in the metropolitan economy (a total of 326,897 jobs) were classified as N.E.C. clerical and kindred jobs.[9] This was the largest number of jobs in any single occupational category. This category includes workers such as bank tellers, cashiers, mail carriers, and real estate appraisers. Hereafter, we use the term "clerical" to refer to this category of employees. Following clerical employees are N.E.C. operatives (including drillers, seamstresses, and manufacturing inspectors), N.E.C. administrators (including credit personnel, postmasters, and purchasing agents), and food service workers.

The total output of local industries in 1986 was $74.6 billion (in 1977 dollars). Manufacturing and services contributed the largest shares of total output. Figure 5

[9]N.E.C. means not elsewhere classified. N.E.C. clerical and kindred workers are clerical workers other than secretaries and stenographers; office machine operators; and insurance adjusters, examiners, and investigators.



Note: See Appendix B for abbreviations.

Source: REMI historical forecast.

Figure 5

RELATIVE CONTRIBUTION TO
TOTAL OUTPUT, 1986

illustrates the relative contributions of manufacturing, services, retail trade, and finance, insurance, and real estate to total output. The first two sectors contributed 40.0% and 19.7%, respectively. Finance, insurance, and real estate accounted for 13% of total output and retail trade accounted for 8.8% of total output. All the remaining sectors together accounted for 18.4% of total output.

The value of purchases by the local area from local sources and sources outside the local area was $76 billion (in 1977 dollars). Refer to Table 10. More than 40 percent (40.3%) of all purchases by the local area were purchases of manufactured products. Following were purchases of services (16.0%), and finance, insurance, and real estate services (15.7%). Although the local area demanded, predominantly, manufactured goods, 74.8% of these goods came from sources outside the local area. This was a consequence of locally manufactured products being relatively more expensive than manufactured goods in markets outside the local area. This was not the case, however, for services, real estate, and construction. Local production satisfied 66.8% of local demand for services, 81.6% of local demand for retail trade, and 82.8% of local demand for construction.

Finally, production costs in the local economy were larger than production costs in the United States as a whole. Labor costs represented the largest component of relative production costs. They were 2.76 times larger than labor costs in the United States as a whole. Fuel costs were 2.29 times larger and intermediate input costs were 2.26 times larger. Mining, construction, and agriculture, forestry, and fishing services had the highest relative labor costs of all industrial sectors. These high relative production costs eroded the competitiveness of locally produced goods and services, especially the competitiveness of manufactured goods.

We have used the results from a historical forecast by the

Table 10

Output Demand by Local Area
(billions of 1977 dollars)

Sector	Percent of Total	Total Demand	Source of Output Demand: Self Supply	Percent	Imports	Percent
Manufacturing	40.27	30.67	7.72	25.2	22.96	74.8
Mining	1.45	1.11	0.09	8.2	1.01	91.8
Contract	0.00					
Construction	3.56	2.71	2.24	82.8	0.47	17.2
Transportation &	0.00					
Public Utilities	7.81	5.95	2.80	47.0	3.15	53.0
Fin., Insur., and	0.00					
Real Estate	15.66	11.93	5.97	50.1	5.95	49.9
Retail Trade	9.43	7.18	5.86	81.6	1.32	18.4
Wholesale Trade	5.49	4.18	3.75	89.6	0.43	10.4
Services	16.00	12.19	8.15	66.8	4.04	33.2
Agri/For/Fish Svc.	0.34	0.26	0.19	73.6	0.07	26.4
Total	100.00	76.18	36.78		39.41	

Note: Fin., Insur., and Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc. denotes Agriculture, Forestry, and Fishing Services.

Source: REMI historical forecast.

Boston Model to characterize the local economy. We focused on the industrial sectors we believe would be affected the most by increased construction investment and tourism. In 1986, services, manufacturing, and retail trade were the most important employment sectors in the Boston metropolitan economy. They employed primarily clerical workers, operatives, administrators, and food service workers. Services and manufacturing relied primarily on local consumption and export activity to generate sectoral employment; and retail trade relied, overwhelming, on local consumption to generate employment in retail trade industries.

In terms of local output, manufacturing, followed by services and finance, insurance, and real estate, was the predominant output sector in the local economy. It exported 75% of its output to the rest of the United States and the rest of the world. Services exported 32% of its output and finance, insurance, and real estate exported 11% of its output to the rest of the United States and the rest of the world. In the light of these economic conditions, we assess the economic impacts of construction investments and increased tourism. We do this in the next chapter.

Chapter 5

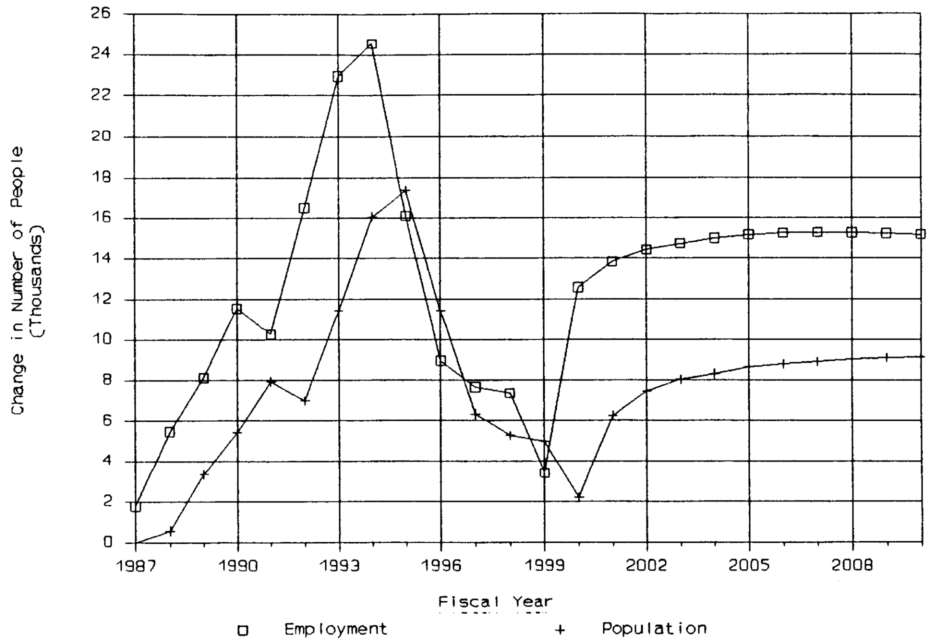
ANALYSIS OF FORECAST RESULTS

In this chapter, we use forecasts from the Boston Model to analyze the economic impacts of construction investments and increased tourism. We assess predicted changes in economic variables, such as population, employment, output, and income, paying particular attention to the services, retail trade, construction, and manufacturing sectors. Because the services and retail trade sectors are the most important employment sectors in the local economy and the manufacturing sector is declining as a producer of employment, it is important for us to assess the possible long-term effects that these policy changes might have. Thus, we examine the forecasted economic effects of construction expenditures from 1987 to 1999 and the effects of the anticipated benefits of water-quality improvements from 2000 to 2010.

As we discussed earlier, we made two simplifying assumptions concerning our simulation of water-quality improvements. First, benefits will begin to accrue in the year 2000. Second, the benefit estimates we use in the simulation accurately represent the water-quality improvements attained during the first 11 years of operation of the pollution control facilities. We understand, however, that annual benefits are unlikely to be the same from year to year and that levels of improved water quality represented by META estimates are unlikely to occur immediately after the projects begin operation. The results that follow represent the difference between a control forecast (a forecast that is absent of any policy changes) and a simulation for the sum of two regions, Suffolk County and the Rest of Metropolitan Boston.

Population and Employment

The creation of new private, nonfarm jobs as a result of the Harbor cleanup will draw workers into the metropolitan region from the rest of the state and from neighboring states, such as New Hampshire and Rhode Island. Thus, the Harbor cleanup program is likely to increase population and employment in the local economy as illustrated in Figure 6. In 1987, construction expenditures will not cause population to increase immediately; however, they will generate more than 1,700 new jobs in the local economy. By 1988, new jobs will stimulate the influx of migrant workers and will increase the population by nearly 600 residents. Both employment and population are predicted to continue growing at an increasing rate until 1993, except for the one-year decline for both employment (1990-1991) and population (1991-1992). This decline is the result of the lower level of proposed construction expenditures by MWRA in 1991 (recall Table 5). By 1993, completion of the most capital-intensive phases of construction will dramatically slow the growth in employment



Note: See Appendix B for abbreviations.

Source: REMI forecasts and Tables A1 and A2.

Figure 6

IMPACT OF HARBOR CLEANUP ON POPULATION AND EMPLOYMENT, 1987 - 2010 (thousands of people)

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and population. By the end of the construction period, population will have increased by more than 97,000 people and employment will have increased by more than 144,000 jobs (refer to Table A1 in the Appendix).

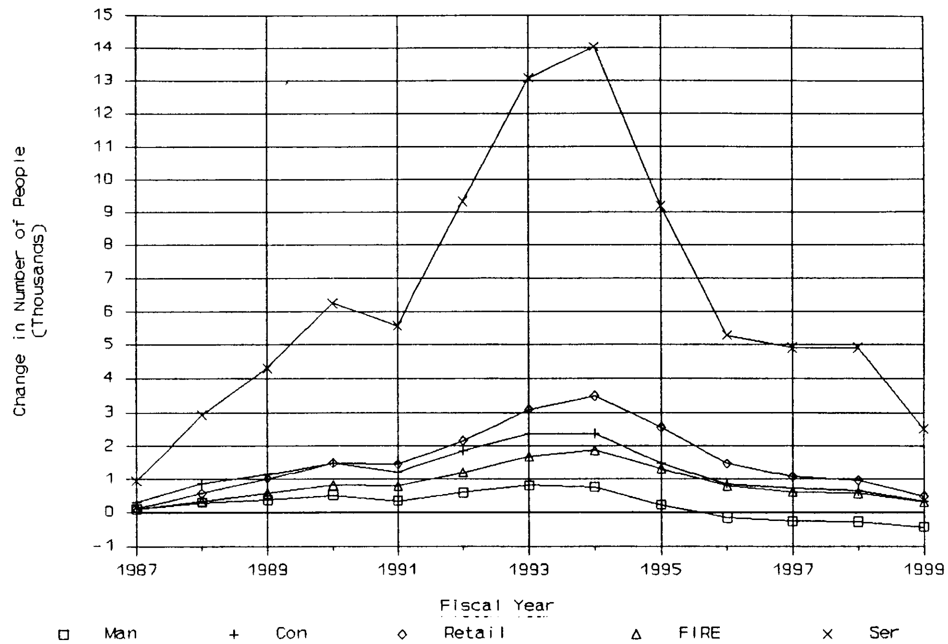
As the pollution control projects go into operation in the year 2000, the resulting increase in recreational use of the Harbor will stimulate an immediate employment increase of

12,591 jobs; population will increase by 2,182 people during this first year. Employment growth will continue at a rate of approximately 14,000 to 15,000 jobs per year. After an initial increase of 6,271 new residents by the second year of operation, population will grow at the rate of 7,400 and 9,200 residents per year. By the year 2010, operation of the pollution control facilities will have created 161,954 jobs and will have increased the population in the local area by 85,850 (refer to Table A2 in the Appendix).

Employment by Sector

We examine, separately, the influence of construction investments and the influence of water-quality improvements on sectoral employment. In both cases, we focus on employment in the manufacturing, the retail trade, the finance, insurance, and real estate, and the services sectors. In addition, for the construction period, we present the changes that occur in the construction sector.

In Figure 7, we illustrate the impact of construction expenditures on employment by industrial sector. Construction requires the largest inputs of services; thus, construction investments will generate the greatest number of new jobs in the services sector. The increase in employment in services will peak in 1994, the year in which the largest construction investments will be made. By 1999, these investments will generate a total of 83,310 service-related jobs. During the



Note: See Appendix B for abbreviations.

Source: REMI forecasts and Table A1.

Figure 7

IMPACT OF CONSTRUCTION INVESTMENTS ON
EMPLOYMENT BY SECTOR, 1987 - 1999
(thousands of people)

first three years of construction, there will be slightly more new construction jobs than retail trade jobs. As rising employment draws more workers to the metropolitan area, the number of new jobs in retail trade will exceed the number of new jobs in construction by 1991. Growing business and residential demand for goods and services, such as clothing, food, and electronic items, will also generate employment growth in retail establishments. Once construction ends, employment in retail trade will decline to the level of employment in the construction sector.

Manufacturing industries, which, traditionally, had led both State and metropolitan economies in terms of employment, will gain only 2,962 jobs as a result of the increase in construction activity. Slow employment growth between 1987 and 1995 will create only 4,080 new jobs; however, during the last four years of the construction period, this sector will lose 27% (1,118) of this increase. In comparison with the mining and the agriculture, forestry, and fishing services sectors that play relatively minor roles in the local economy, this increase will be the smallest employment increase (2.1%) stimulated by construction activity. This result indicates that the construction sector will require relatively few additional inputs from local manufacturing industries due to construction investments. Furthermore, this result is consistent with economic trends that show the decline of the manufacturing sector in the metropolitan economy.

To give some idea of how each industrial sector will contribute to the increase in employment, we show in Table 11 the percent of the total increase that each sector will represent. The services sector will account for nearly 58% (83,310) of all new jobs that will be created as a result of the construction expenditures. Within this sector, medical services will account for the largest share of the increase in

Table 11

Construction Expenditure Impact
Change in Employment by Sector
Fiscal Years 1987 - 1999
(number of employees)

Rank	Sector	% of Increase	Employees
	Manufacturing	2.05	2962
7	Durables	1.59	2299
8	Nondurables	0.46	663
10	Mining	0.01	11
3	Contract Construction	10.90	15764
6	Transportation & Public Utilities	3.75	5418
4	Fin., Insur. & Real Estate	7.65	11066
2	Retail Trade	13.83	20011
5	Wholesale Trade	4.05	5855
1	Services	57.59	83310
9	Agri/For/Fish Svc	0.18	254
	Total Employment Change	100.00	144651

Note: Fin., Insur., & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: Author's calculations based on Table A1 in the Appendix and on REMI forecast.

services. Services will be followed by retail trade, which will account for approximately 14% of all new jobs (20,011); and by contract construction, which will account for 11% of all new jobs (15,764). Forecasts that more than 70% of all new jobs will be services and retail trade jobs demonstrates the significance of these sectors to the local economy.

We examined forecasted increases in employment by occupation and found that construction activity will induce the greatest demand for clerical workers, secretaries, and administrators. We show this in Table 12. We expect that construction activity will increase the demand for clerical workers, such as clerical assistants, shipping and receiving clerks, cashiers, and payroll and timekeeping clerks. There will be an increase of more than 19,000 employees in this category between 1987 and 1999; this increase will represent 13% of the total increase in employment. The demand for legal and medical secretaries will add 13,256 secretaries by 1999 (9% of the total employment increase), and the demand for administrative services will add 11,345 administrators (8% of the total employment increase), followed by demand for construction workers, lawyers and judges, and accountants.

As we discussed in previous chapters, the pollution control project will stimulate, primarily, increased recreational use of Boston Harbor. This increase in recreation activity will stimulate demand primarily in service-related industries and retail establishments.

Table 12

Construction Expenditure Impact
Change in Occupational Employment

Category	Fiscal Year												
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Clerical & Kindred	137	656	1029	1488	1385	2139	3023	3323	2309	1315	1049	996	500
Secretaries	157	469	695	1004	895	1482	2075	2237	1466	840	772	771	393
Administrators	141	441	655	925	825	1298	1792	1917	1270	708	577	544	252
Construction	141	379	509	673	562	851	1101	1117	711	404	337	306	158
Lawyers & Judges	114	323	465	675	588	1016	1420	1520	967	559	560	575	299
Accountants	93	267	386	559	490	836	1168	1251	800	459	449	457	234
Food Service	45	186	314	452	435	656	925	1022	720	420	314	288	144

Source: REMI forecast

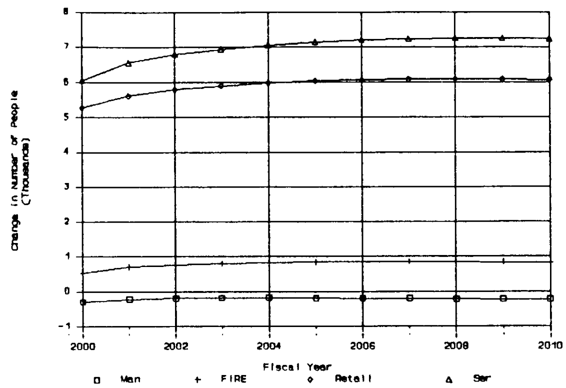
Consequently, the services and retail trade sectors will show the largest increases in employment. We illustrate this in Figure 8. The fairly constant annual change in employment that is forecasted for each of the sectors in Figure 8 is a function of the equal annual estimates of recreation benefits. Had benefits been estimated according to the expected growth in population, we might have seen annual increases that were more striking.

In Table 13, we show the relative contribution each sector will make to the increase in employment. Of the total employment increase forecasted for this period (161,954 jobs), these sectors will contribute 47% and 40% of all new jobs, respectively. The employment increase in the finance, insurance, and real estate sector will be only 5% of the forecasted total increase in employment. Manufacturing will suffer a constant loss of employment and will lose a total of 2,384 jobs between 2000 and 2010.

In terms of occupational employment, improvements in water quality will create more food service jobs than any other type of job. The local area will demand approximately 4,000 additional food service employees each year. Following, will be clerical employees, personal service workers, and administrators. We show these results in Table 14.

Output by Sector

The cleanup of Boston Harbor is expected to increase the

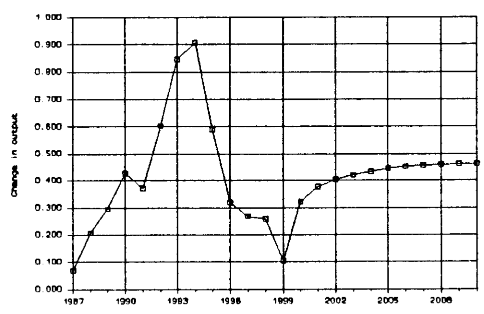


Note: See Appendix B for abbreviations.

Source: REMI forecasts and Table A2.

Figure 8

IMPACT OF RECREATION BENEFITS ON
EMPLOYMENT BY SECTOR, 2000 - 2010
(thousands of people)



Note: See Appendix B for abbreviations.

Source: REMI forecasts and Tables A3 and A4.

Figure 9

IMPACT OF HARBOR CLEANUP ON
LOCAL OUTPUT, 1987 - 2010
(billion of 1977 dollars)

Table 13

Project Benefits Impact
Change in Employment by Sector
Fiscal Years 2000 - 2010

Rank	Sector	% of Increase	Number of Jobs
	Manufacturing	-1.47	-2384
10	Durables	-1.63	-2636
8	Nondurables	0.16	252
9	Mining	.00	0
6	Contract Construction	2.01	3258
4	Transportation & Public Utilities	3.36	5440
3	Fin., Insur. & Real Estate	5.38	8715
2	Retail Trade	40.15	65026
5	Wholesale Trade	3.06	4953
1	Services	47.36	76702
7	Agri/For/Fish Svc	0.15	244
	Total Employment Change	100.00	161954

Note: Fin., Insur., & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: Author's calculations based on Table A2 in the Appendix and on REMI forecast.

Table 14

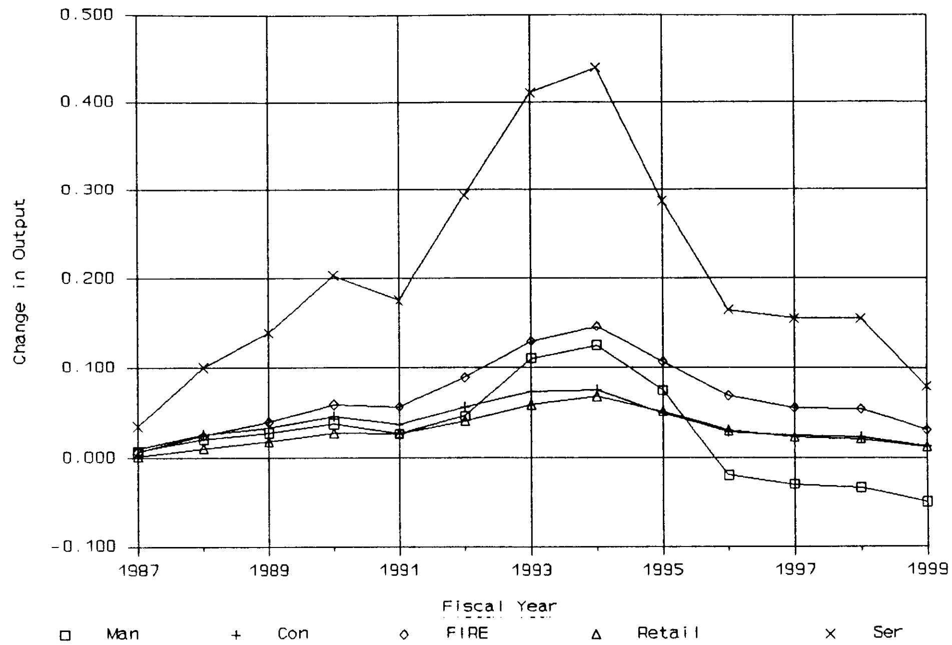
Project Benefits Impact
Change in Occupational Employment
(number of employees)

Category	Fiscal Year										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Food Service	3700	3825	3898	3950	3993	4031	4059	4081	4100	4115	4127
Clerical & Kindred	1505	1762	1859	1910	1946	1973	1984	1986	1983	1975	1962
Personal Service	1377	1425	1453	1474	1493	1509	1523	1535	1546	1555	1564
Administrators	1020	1133	1183	1210	1231	1246	1252	1254	1253	1250	1244
Cleaning	864	923	950	967	980	992	999	1005	1009	1012	1013

Source: REMI forecast

output of local industries as shown in Figure 9 above. The change in output will follow the same trend as the changes in employment and population. First, rapid growth in output due to increases in direct and indirect inputs into the construction sector will give way to a rapid decline in output growth as construction comes to an end. The increases in output will peak in 1994, when the largest construction investments will be made. The increase in output at the end of the construction period will be only slightly higher than the forecasted increase for the beginning of the period. Second, output will grow quickly during the first year of operation of the pollution control facilities, but thereafter, it will grow more slowly and at a fairly constant rate. The fairly constant annual increase will be due, again, to the equal annual benefit estimates. The total increase in output over the entire period from 1987 to 2010 will be approximately $10 billion (in 1977 dollars). Refer to Tables A3 and A4 in the Appendix.

We first examine what the changes in local output will be due to construction investments. Figure 10 illustrates the forecasted change in local output for the services, the finance, insurance, and real estate, the contract construction, the retail trade, and the manufacturing sectors. As in the case of employment, services is predicted to contribute the most to the forecasted increase in output, and manufacturing is predicted to lose output production during



Note: See Appendix B for abbreviations.

Source: REMI forecasts and Table A3.

Figure 10

IMPACT OF CONSTRUCTION INVESTMENTS
ON OUTPUT BY SECTOR, 1987 - 1999
(billions of 1977 dollars)

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the last half of the construction period. According to Table 15, services will generate slightly more than 50% of the increase in total output; and finance, insurance, and real estate will generate almost 17% of the increase. Each of the remaining sectors will generate less than 10% of the increase in total output.

Improvements in water quality will increase local output

Table 15

Construction Expenditure Impact
Change in Output by Sector
Fiscal Years 1987-1999
(billions of 1977 dollars)

Rank	Sector	% of Increase	Value of Output
	Manufacturing	3.26	0.172
8	Durables	1.50	0.079
7	Nondurables	1.76	0.093
10	Mining	0.08	0.004
3	Contract Construction	9.49	0.500
4	Transportation & Public Utilities	7.54	0.397
2	Fin., Insur. & Real Estate	16.55	0.872
5	Retail Trade	7.47	0.394
6	Wholesale Trade	5.34	0.281
1	Services	50.10	2.640
9	Agri/For/Fish Svc	0.17	0.009
	Total Change in Output	100.00	5.270

Note: Fin., Insur., & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: Author's calculations based on Table A3 in the Appendix and on REMI forecast.

between 2000 and 2010. Although output will not increase to the levels forecasted for the construction expenditures, the increase will be sustained over a much longer period (recall Figure 9). Local industries will produce approximately $400 million worth of output each year due to increased recreational use of the Harbor. Over the 10-year period, local industries will have produced an additional $4,689 million worth of output (in 1977 dollars). Services, retail trade, and finance, insurance, and real estate will contribute the most to this increase (Table 16). They will contribute, respectively, 39.1%, 25.0%, and 24.7% of the projected increase in output. Manufacturing industries will show the only loss of output. By the year 2010, the steady loss of output in this sector will total 6.3% of the expected increase in output.

Personal Income

We use personal consumption expenditures (PCE) and real disposable income to assess the effects of the environmental policy on personal income. Given that changes in regional demand will influence prices in the local area, we examine the change in this variable, as well. We illustrate the changes in these variables in Figure 11. We present the supporting tables for Figure 11 in the Appendix (Tables A5 and A6).

During the first six years of construction, regional

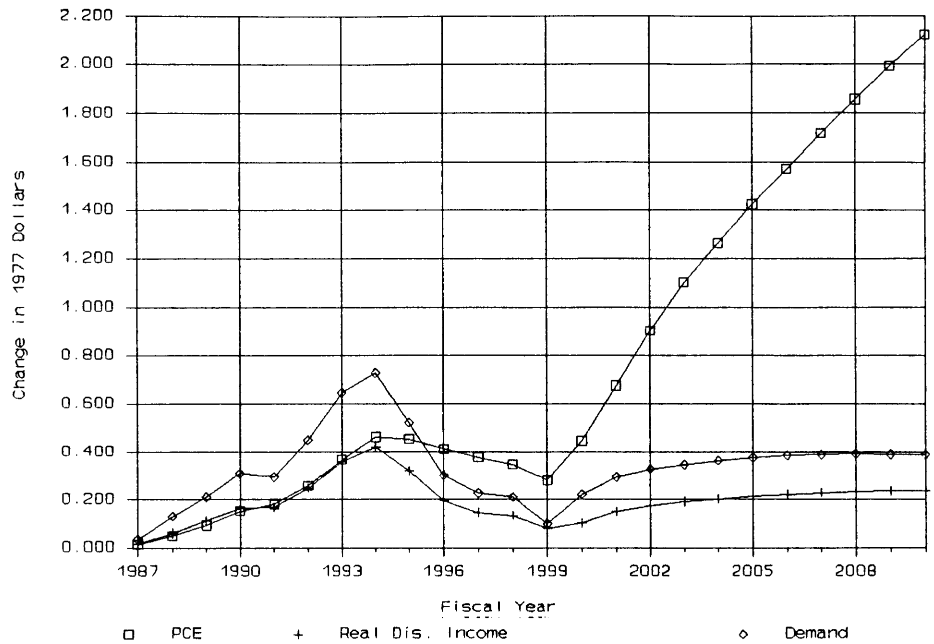
Table 16

Project Benefits Impact
Change in Output by Sector
Fiscal Years 2000 - 2010
(billions of 1977 dollars)

Rank	Sector	% of Increase	Value of Output
	Manufacturing	-6.27	-0.294
10	Durables	-8.76	-0.411
7	Nondurables	2.49	0.117
9	Mining	0.05	0.002
6	Contract Construction	2.87	0.135
4	Transportation & Public Utilities	8.04	0.377
3	Fin., Insur. & Real Estate	24.69	1.158
2	Retail Trade	25.01	1.173
5	Wholesale Trade	6.29	0.295
1	Services	39.10	1.833
8	Agri/For/Fish Svc	0.22	0.010
	Total Change in Output	100.00	4.689

Note: Fin., Insur., & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: Author's calculations based on Table A4 in the Appendix and on REMI forecast.



Note: See Appendix B for abbreviations.

Source: REMI forecast and Tables A5 and A6.

Figure 11

IMPACT OF HARBOR CLEANUP ON
INCOME AND DEMAND, 1987 - 2010
(billions of 1977 dollars)

demand will grow at an increasing rate and will exceed the growth in real disposable income. This excess regional demand will cause PCE to increase at an increasing rate, indicating inflation; we expect to see a certain amount of inflation during the construction period. When construction investments begin to decline, growth rates for all three variables will decline; however, the growth rate for PCE will remain larger than the growth rate for both regional demand and real disposable income, until the end of the construction period. Thus, construction investments will cause higher levels of inflation in the local economy than before the construction period began.

Once the recreational benefits begin to accrue in the year 2000, personal consumption expenditures will increase dramatically; real disposable income will not keep pace with inflation. Even though we will see some inflation during this period, the dramatic rise in PCE is higher than we believe is reasonable; the order of magnitude is out of line with what we expected.

Summary of Forecast Results

Both construction investment and increased recreational use of Boston Harbor are expected to stimulate the largest employment increases in services. The total increase in employment will be comparable for both construction investment and recreation effects. The effects of the construction investments will be large initially, but they will decrease rapidly as construction ends. The effects of the recreation benefits will not be as dramatic due to the nature of the estimates; the recreation benefit estimates of META staff do not change as population changes. The annual employment increases will be large but, they will be fairly constant over the 10-year forecast period.

The recreation benefits will stimulate more employment in retail trade industries than will the construction investments. More than 76% of the total expected increase in retail trade employment will be due to the increase in recreation benefits. For the finance, insurance and real estate sector, construction investments will generate 56% of the total increase in employment. In terms of occupational employment, recreation benefits will stimulate the most demand for food service workers, and construction investments will stimulate the most demand for clerical, secretarial, and administrative workers.

The services sector will gain the largest increase in output due to the cleanup program. Given that services represents the largest inputs into construction, output growth in this sector, due to the construction investments alone, will be 60% of the total increase in output for the entire period from 1987 to 2010. Recreation benefits will be primarily responsible for the output growth in retail trade, and in finance, insurance and real estate. Recreation benefits will generate $1.1 billion worth of output in each of these sectors. In comparison, construction investments will generate $394 million and $872 million, respectively, in these sectors.

Of the four sectors we focused on in our analysis, we find that the manufacturing sector will experience the smallest gains in employment and output. For employment in this sector, there will be a net gain of only 578 jobs over the entire forecast period. Construction investments will generate 2,962 manufacturing jobs but, the impact of recreation benefits will results in a loss of 2,384 manufacturing jobs. For this sector, construction investments will induce an increase in manufacturing output of $172 million; however, the increase in tourism in the area will induce a loss of $294 million worth of manufacturing output. The projected net output effect for this sector will be a loss of $122 million of output. Possible reasons for the small net employment effect and the net loss of output in manufacturing are the following:

1) resources will be drawn from manufacturing to other industrial sectors;
2) continued restructuring in the manufacturing industries will reduce the number of jobs;
3) higher production costs will make locally manufactured goods less attractive in both local and export markets; and
4) relatively higher rental and labor costs within the metropolitan area will induce manufacturing establishments to relocate outside of the local area.

In the next chapter, we summarize our findings and present our conclusions.

Chapter 6

Summary and Conclusions

In this thesis, we assessed the economic repercussions of environmental policy recommendations to clean up Boston Harbor. We showed that construction investments, which increase the direct and indirect inputs into the construction sector, are expected to stimulate substantial increases in output demand in the local economy. We also showed that improvements in water quality are expected to stimulate increased recreational use of Boston Harbor, which, in turn, will promote increased spending and business activity in the local area. To simulate the construction phase of the Harbor cleanup, we used projections of annual construction expenditures (MWRA, 1989). To simulate the impact of improved water quality, we used estimates of gross annual recreation benefits (META Systems, Inc., 1985).

As a basis for utilizing META estimates of the benefits to society from improvements in water quality, we outlined, in Chapter two, a few of the basic concepts and approaches that analysts use to estimate these benefits. Analysts use increases in consumer surplus to estimate recreation and nonuser benefits; these are the predominant benefits associated with improvements in water quality. They measure two components of consumer surplus: the higher price that current users and nonusers are willing to pay for improvements; and the increased use of the water resource generated by the improvements.

To measure these two components of consumer surplus, analysts use the travel cost multinomial, logit model and the contingent valuation approach. By using the former, analysts can describe the probability that an individual will choose to visit each of a subset of recreation sites; that probability is conditional on the total number of visits the individual takes. This approach requires actual improvements in water quality. The latter relies on analysts questioning both users and nonusers of a water resource to determine their willingness to pay, contingent on hypothetical changes in water quality. In both approaches, analysts use regression results based on stated values to provide statistical estimates of the shift in willingness to pay with improvements in water quality and thus, the value of the improvement in water quality.

Analysts at META Systems, Inc. used these two measurement approaches, and recreation studies for the Boston area, to estimate the recreation benefits that might result from the cleanup of Boston Harbor. In addition to recreation benefits, META analysts estimated benefits from increased commercial fishing activity, fewer water-related illnesses, improved aesthetic quality, and restored ecological systems. They showed that, of these benefits, increases in recreation are expected to be the largest benefits associated with potential improvements in water quality. Moreover, META analysts indicated that, despite the fact that their estimates understate the actual range of benefits that might occur, they are still fairly large.

To assess the economic impacts of the Harbor cleanup on the metropolitan economy, we used the META calculations of annual recreation benefits and the MWRA projections of annual construction expenditures as policy alternatives in the Boston Forecasting and Simulation Model. The Boston Model provided us with details about the changes in local output and employment demand that will be stimulated by the environmental policy alternatives. It enabled us to determine, based on endogenous economic relationships, how these policy changes might be transmitted throughout the local economy over the long-run. We analyzed the forecasted impacts from the Boston Model for the period 1987 to 2010, noting the following results.

The effects of construction investments will be short-lived. Even though they will generate significant positive employment and output effects initially, these effects will decline quickly as construction comes to an end. Services will benefit the most from increases in construction investments. It will be followed, distantly, by the retail trade, and the finance, insurance, and real estate sectors. The annual increases in tourism will stimulate the greatest demands for output and employment of the services and retail trade sectors. The increase in economic activity during this period will be sustained over the long-term.

During both phases of the cleanup process, manufacturing industries will experience the smallest beneficial effects: Net employment creation over the entire forecast period will be less than 600 jobs and there will be a net loss of manufacturing output. Growth in regional demand stimulated by construction investments will generate some inflation in the local economy during the construction period; however, during the period from 2000 to 2010, prices will increase dramatically. The PCE indicates that inflation will continue even after the end of construction. While this conclusion is consistent with experiences elsewhere, the level of increase, as shown by the model, appears excessive.

In conducting an economic impact assessment of the Boston Harbor cleanup, we have shown that construction investments and potential recreation benefits to society from improved water quality will stimulate substantial increases in employment and output in metropolitan Boston; furthermore, these increases will be large despite the fact that the estimates of recreation benefits (META, 1985) grossly understate the actual increase in the benefits to society. We did not conduct a benefit-cost analysis of the Harbor cleanup. We assessed the economic ramifications of the environmental policy changes; therefore, given that we had access only to estimates of gross benefits, we used these estimates (of gross recreation benefits) in our analysis. In conducting future research on this topic, analysts might consider the impact of benefits that have been discounted back to the time the construction investments were made. In addition, analysts might also estimate the resulting increases in employment and output, less the input costs of the stimulated economic activity.

It is important to assess how the economy of metropolitan Boston might respond to the construction of new pollution control facilities and to the anticipated improvements in water quality. Decision-makers can use this information to capitalize on opportunities for new business and employment creation. Being able to take advantage of potential revenue-generating opportunities is particularly important, especially when local financial resources for new programs are scarce.

If decision-makers can predict the magnitude of increases in tourism and recreation, for example, then, they can allocate scarce resources in such a way to enable the local economy to benefit from the stimulated economic activity. Expanded recreational (fishing, boating, swimming) and commercial (fishing) use of Boston Harbor and of the Boston Harbor Islands will augment demand for services, such as transportation to and from the Boston Harbor Islands, piers and marinas for private use, access to (and maintenance of) public beaches, and landing areas for commercial fishing activity. Thus, to satisfy this demand and capture, more fully, the revenues that will be generated from the increased recreational and commercial use, decision-makers can these results to develop appropriate spending and management policies.

If policy-makers desire to reduce losses in specific sectors of the economy, the results of an impact assessment can be useful in developing measures to lessen those losses. Local manufacturing, which is expected to suffer losses of employment and output, is one sector that might benefit in this case. Commercial fishing is yet another example; it is an important economic and natural resource for the Boston area. Even though we were unable to use the Boston Model to assess the impact of improvements in water quality on local commercial fishing activity, policy-makers can use the information generated by an economic impact analysis to promote future development of commercial fishing in Boston Harbor. Given that competing demands for use of the Harbor is increasing dramatically, commercial fishing is being replaced by more profitable non-water-dependent uses, such as office buildings, shopping malls, and condominiums (NOAA, 1987, p. 95). Policies that will expand vital commercial fishing facilities will be important for sustaining the natural resource that this activity represents and for capturing the economic resources it generates.

Concerning the application of our study to other metropolitan areas, analysts cannot use our results to generalize about the effects of water pollution abatement policies in coastal cities throughout the United States; however, they can gain insights about the nature of potential economic impacts in their own local economies. Because we show in our analysis that investments in water pollution control in Boston Harbor are expected to stimulate substantial increases in economic activity, analysts and decision-makers in other coastal cities can use our study as an illustration of the fairly strong relationship between improvements in water quality and induced economic activity. This could be useful in generating greater legislative and financial support for investments in water pollution control programs nationwide.

Appendix A

Table A1

Construction Expenditure Impact
Annual Change in Employment By Sector
(number of employees)

Sector	Fiscal Year 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Manufacture	108	300	387	516	358	602	814	763	232	-155	-251	-275	-437
Durables	91	244	303	407	277	471	628	577	161	-126	-190	-208	-336
Nondurables	17	56	84	109	81	131	186	186	71	-29	-61	-67	-101
Nonmanufacture													
Mining	0	0	1	1	1	1	2	2	1	2	0	0	0
Contract Construction	333	871	1148	1500	1232	1866	2377	2375	1483	850	726	656	347
Transportation & Public Utilities	76	223	321	456	393	633	879	933	601	314	258	240	91
Fin., Insur. & Real Estate	93	348	579	819	788	1212	1708	1886	1320	801	619	584	309
Retail Trade	123	577	1019	1500	1453	2162	3092	3489	2562	1485	1080	972	497
Wholesale Trade	69	222	336	480	427	688	966	1037	673	348	272	252	85
Services	963	2926	4308	6265	5577	9316	13084	14041	9184	5285	4917	4917	2527
Agri/For/Fish Svc	1	6	12	18	18	26	39	46	35	21	14	12	6
Total Employment	1766	5473	8111	11555	10247	16506	22961	24572	16091	8951	7635	7358	3425
Population	0	566	3327	5436	7924	6973	11430	16048	17370	11427	6319	5277	4383

Total Change
Employment 144651
Population 97080

Note: Fin., Insur. & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: REMI forecast

Table A2

Project Benefits Impact
Annual Change in Employment By Sector

Sector	Fiscal Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manufacturing	-304	-229	-196	-190	-188	-195	-202	-208	-216	-224	-232
Durables	-320	-270	-243	-233	-225	-225	-223	-222	-223	-225	-227
Nondurables	16	41	47	43	37	30	21	14	7	1	-5
Nonmanufacturing											
Mining	0	0	0	0	0	0	0	0	0	0	0
Contract Construction	189	260	285	298	311	319	322	322	321	318	313
Transportation & Public Utilities	459	500	513	515	514	511	504	496	486	476	466
Fin., Insur. & Real Estate	542	706	770	805	829	848	855	853	847	837	823
Retail Trade	5269	5615	5793	5897	5978	6043	6075	6091	6096	6091	6078
Wholesale Trade	371	427	450	459	469	473	472	468	463	455	446
Services	6053	6559	6795	6940	7053	7145	7199	7228	7245	7247	7238
Agri/For/Fish Svc	12	17	20	21	23	24	25	25	25	26	26
Total Employment	12591	13855	14430	14745	14989	15168	15250	15275	15267	15226	15158
Population	2182	6271	7440	8025	8300	8640	8794	8916	9025	9105	9152

Total Change
Employment 161954
Population 85850

Note: Fin., Insur. & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: REMI forecast

Table A3

Construction Expenditure Impact
Annual Change in Output by Sector
(billions of 1977 dollars)

Sector	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Fiscal Year												
Manufacture	0.007	0.021	0.028	0.038	0.027	0.047	0.111	0.125	0.075	-0.020	-0.031	-0.034	-0.050
Durables	0.006	0.016	0.021	0.028	0.019	0.033	0.046	0.041	0.004	-0.023	-0.031	-0.034	-0.047
Nondurables	0.001	0.005	0.007	0.010	0.008	0.013	0.019	0.020	0.011	0.003	.000	.000	-0.004
Nonmanufacture													
Mining	.000	.000	.000	.000	.000	.000	0.001	0.001	0.001	.000	.000	.000	.000
Contract Construction	0.010	0.026	0.034	0.046	0.037	0.057	0.074	0.076	0.049	0.029	0.025	0.024	0.013
Transportation & Public Utilities	0.005	0.014	0.020	0.030	0.027	0.043	0.062	0.067	0.046	0.026	0.023	0.023	0.012
Fin., Insur. & Real Estate	0.007	0.025	0.040	0.060	0.057	0.089	0.129	0.146	0.107	0.069	0.056	0.055	0.032
Retail Trade	0.002	0.010	0.018	0.028	0.027	0.041	0.059	0.068	0.052	0.031	0.023	0.021	0.012
Wholesale Trade	0.003	0.010	0.015	0.022	0.020	0.032	0.045	0.049	0.033	0.018	0.015	0.014	0.006
Services	0.035	0.101	0.139	0.203	0.176	0.294	0.411	0.439	0.287	0.165	0.155	0.155	0.080
Agri/For/Fish Svc	.000	.000	.000	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	.000
Total 5.261	0.069	0.207	0.294	0.426	0.371	0.603	0.845	0.907	0.589	0.319	0.268	0.258	0.105

Note: Fin., Insur. & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: REMI forecast

Table A4

Project Benefits Impact
Annual Change in Output by Sector
(billions of 1977 dollars)

Sector	Fiscal Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manufacturing	-0.034	-0.026	-0.023	-0.023	-0.023	-0.024	-0.025	-0.026	-0.028	-0.030	-0.032
Durables	-0.043	-0.037	-0.035	-0.035	-0.034	-0.035	-0.036	-0.037	-0.038	-0.040	-0.041
Nondurables	0.009	0.011	0.012	0.012	0.012	0.011	0.011	0.010	0.010	0.009	0.009
Nonmanufacturing											
Mining	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Contract Construction	0.008	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
Transportation & Public Utilities	0.027	0.032	0.033	0.034	0.035	0.036	0.036	0.036	0.036	0.036	0.036
Fin., Insur. & Real Estate	0.071	0.088	0.095	0.101	0.105	0.110	0.113	0.116	0.118	0.120	0.121
Retail Trade	0.090	0.098	0.102	0.105	0.107	0.109	0.111	0.112	0.113	0.113	0.114
Wholesale Trade	0.021	0.024	0.026	0.026	0.027	0.028	0.028	0.029	0.029	0.029	0.029
Services	0.138	0.152	0.159	0.163	0.167	0.171	0.174	0.176	0.177	0.178	0.179
Agri/For/Fish Svc	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total Output 4.689123	0.321	0.377	0.404	0.420	0.433	0.444	0.451	0.456	0.459	0.461	0.461

Note: Fin., Insur. & Real Estate denotes Finance, Insurance, and Real Estate.
Agri/For/Fish Svc denotes Agriculture, Forestry, and Fishing Service.

Source: REMI forecast

Table A5

Construction Expenditure Impact
Change in Personal Income
(billions of 1977 dollars)

	Fiscal Year												
Variable	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PCE - Price Index	0.012	0.049	0.094	0.153	0.181	0.260	0.369	0.464	0.455	0.413	0.379	0.350	0.283
Real Dis. Income	0.013	0.061	0.113	0.165	0.168	0.248	0.362	0.421	0.321	0.195	0.146	0.134	0.080
Regional Demand	0.035	0.131	0.211	0.312	0.296	0.451	0.648	0.728	0.522	0.302	0.227	0.210	0.100

Note: PCE denotes Personal Consumption Expenditures.
Real Dis. Income denotes Real Disposable Income.

Source: REMI forecast

Table A6

Project Benefits Impact
Change in Personal Income
(billions of 1977 dollars)

Category	Fiscal Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
PCE - Price Index	0.488	0.676	0.904	1.103	1.263	1.422	1.571	1.718	1.858	1.994	2.125
Real Dis. Income	0.102	0.151	0.174	0.191	0.203	0.215	0.223	0.229	0.233	0.236	0.237
Regional Demand	0.222	0.296	0.329	0.348	0.366	0.379	0.386	0.391	0.392	0.392	0.390

Note: PCE denotes Personal Consumption Expenditures.
Real Dis. Income denotes Real Disposable Income.

Source: REMI forecast

Appendix B

Abbreviations

Note: Man/Manu denotes manufacturing.

Con denotes contract construction.

FIRE denotes finance, insurance, and real estate.

Retail denotes retail trade.

Ser/Serv denotes services.

Other includes mining, contract construction, transportation and public utilities, wholesale trade, and agriculture, forestry, and fishing services.

PCE denotes personal consumption expenditures.

Real Dis. Income denotes real disposable income.

Demand denotes regional demand.

BIBLIOGRAPHY

Caulkins, Peter, C. Binkley, C. Ruf, and C. Miller. 1988. "The Role of Economic Benefits Analysis in Funding Marine Combined Sewer Overflow Projects--Case Study of Boston Harbor." Journal of the Water Pollution Control Federation, Vol. 60, pp. 1275-1280.

Division of Marine Fisheries. 1985. Massachusetts Marine Fisheries: Economic, Environmental and Management Problems Facing Massachusetts' Commercial and Recreational Marine Fisheries, edited by David Pierce. Boston, Massachusetts.

Dumanoski, Dianne. 198_. "Who Speaks For The Harbor?" The Boston Globe. ( ). Boston, Massachusetts: The Boston Globe. p. 16.

Economic Report of the President. 1988. Washington, D.C.: United States Government Printing Office.

Feenberg, Daniel and Edwin Mills. 1980. Measuring the Benefits of Water Pollution Abatement. New York, N.Y.: Academic Press.

Greenley, Douglas A., R.G. Walsh, and R.A. Young. 1982. Economic Benefits of Improved Water Quality: Public Perceptions of Option and Preservation Values. Studies in Water Policy and Management, No. 3. Boulder, Colorado: Westview Press.

Haar, Charles M. 1986. Of Judges, Politics and Flounders: Perspectives on the Cleaning Up of Boston Harbor. Cambridge, Massachusetts: Lincoln Institute of Land Policy.

Kneese, Allen V. 1984. Measuring the Benefits of Clean Air and Water. Washington, D.C.: Resources for the Future, Inc.

Massachusetts Water Resources Authority. 1988. Annual Report. Boston, Massachusetts: MWRA.

Massachusetts Water Resources Authority. 1989. Proposed Capital Improvement Program: Fiscal Year 1990 to 1992. Boston, Massachusetts: MWRA.

META SYSTEMS, INC. 1985. "A Methodological Approach to an Economic Analysis of the Beneficial Outcomes of Water Quality Improvements From Sewage Treatment Plant Upgrading and Combined Sewer Overflow Controls." Prepared for the Office of Policy Analysis, Environmental Protection Agency, Washington, D.C.

National Oceanic and Atmospheric Administration (NOAA) and United States Environmental Protection Agency (EPA). 1987. Boston Harbor and Massachusetts Bay: Issues, Resources, Status, and Management. Edited by Betsy Brown. Washington, D.C.: United States Department of Commerce.

Pleeter, Saul. 1977. "Methodologies of Economic Impact Analysis: An Overview." In Economic Impact Analysis: Methodology and Applications, edited by Saul Pleeter. The Hague, The Netherlands: Martinus Nijhoff Publishing. pp. 7-31.

Sivitanidou, Rena, and Karen R. Polenske. 1988. "Assessing Regional Economic Impacts with Microcomputers". Journal of the American Planning Association. (Winter 1988), pp. 101-106.

Smith, Kerry V. and W.H. Desvousges. 1986. Measuring Water Quality Benefits. Boston, Massachusetts: Kluwer-Nijhoff Publishing.

Treyz, George I, D.J. Ehrlich, M.S. Depillis, Jr., M.J. Larson, and S.N. Page, Jr. 1986. The Boston Metro Two-Area FS-53 Forecasting and Simulation Model. Amherst, MA: Regional Economic Models, Inc.

Tyre, Larry. 1988. "Water, Sewer Bills To Be About $60 Higher Over A Year." The Boston Globe. (February 25). Boston, Massachusetts: The Boston Globe. p. 1.