

HC79.A4
C83



Cost of Air and Water Pollution Control 1976-1985



our
raft

001R76003





This review draft of the proposed report, "Cost of Air and Water Pollution Control 1976-1985," is a xerox copy produced from the WORD ONE automated word processing system. This system uses symbol and letter combinations to code different type fonts for the photocomposition process that will ultimately produce the final report copy. These symbol/letter codes, i.e., \$a, \$b, \$c, \$d, \$e, \$s, and \$t, appear in this interim copy at the beginning and ending of chapter heads, paragraph titles, and tables. These codes will, of course, be removed when the final production process is accomplished. The following sample page has been included to serve as an example of the final report's format.

677091-64

Section Three

THE ECONOMICS OF WATER POLLUTION CONTROL

Chapter 1 Summary

The economics of controlling water pollution encompasses both the expected benefits and the probable costs of control. The principal findings in the control cost area are summarized below; benefits of water pollution control are discussed in the next chapter of this section.

5. INDUSTRIAL CONTROL COSTS

Introduction

The extent of water pollution and the costs of treating it vary significantly among industries and among the firms within an industry; therefore, it is important to examine the structure, production methods, sources of pollution, effluent standards, and wastewater control technology for each industry. The following sections of this chapter briefly summarize the relevant characteristics of each industry and report the estimated annual abatement costs attributable to achieving full compliance with the 1977 (BPT) and 1983 (BAT) effluent standards.

MODELING AN INDUSTRY

The plants in an industry have various options by which to comply with the water pollution standards. In general they may

1. Fully treat their effluents.
2. Pretreat their effluents and discharge to a municipal system.
3. Change their manufacturing process.

Table 24.
Pollution Control Costs as a Percentage
of Almon Scenario GNP

	1975	1977	1980	1983	1985
Air Stationary Source Costs					
Capital Costs	0.60%	0.47%	0.30%	0.18%	0.11%
O&M Costs	0.42%	0.37%	0.43%	0.38%	0.34%
Water Industrial Costs					
Capital Costs	0.26%	0.36%	0.52%	0.48%	0.06%
O&M Costs	0.02%	0.02%	0.23%	0.27%	0.52%
Water Municipal Costs					
Capital Costs	0.36%	0.39%	0.36%	0.07%	0.02%
O&M Costs	0.03%	0.05%	0.12%	0.11%	0.11%

ECONOMIC FORECASTING IN THE SEAS SYSTEM

Economic forecasting within the SEAS system takes place in a context which meshes the features of a traditional input-output (I/O) model and econometric model-building. The basic structural economic component of SEAS, INFORUM¹, is not a typical economic input-output model. It is, to a substantial degree, a combined econometric-I/O approach to economic forecasting.

$$\frac{i(1+i)^N}{(1+i)^N - 1}$$

Table 10.
General Projections of the Reference Scenarios (S1),
1975-1985

Statistics	Value In			Annual Percentage Change			
	1975	1985	1975-85	1975-77	1977-80	1980-83	1983-85
Population (Millions)	213.9	235.7	0.97	0.89	0.97	1.02	1.00
Labor Force (Millions)	93.8	107.7	1.40	1.71	1.62	1.25	0.96
Unemployment Rate (%)	8.4	4.4	-6.38	-8.07	10.66	-3.04	-2.94
Disposable Income Per Capita (1975 \$)	4,553	5,753	4.94	5.16	7.96	3.29	2.74
Gross National Product (Trillion 1975 \$)	1,470	2,365	4.87	6.43	6.50	3.34	3.18
Personal Consumption Expenditure	933	1,563	5.30	4.87	7.55	4.36	3.79
Investment	222	380	5.59	13.69	6.43	1.85	2.31
Government Expenditures	307	414	3.05	2.99	3.74	2.68	2.64
Federal	117	136	1.61	71	70	2.58	2.43

Table of contents

Section Four-A COMPREHENSIVE ASSESSMENT OF POLLUTION CONTROL: IMPACT MEASUREMENT UNDER ALTERNATIVE FUTURES

<u>Chapter</u>		<u>Page</u>
1	Impact Estimation Using the Strategic Environmental Assessment System (SEAS)	4-3
2	Scenario Assumptions	4-7
3	Macro-Analysis Results	4-14
4	Sectoral Analyses Results	4-79
5	Estimating Pollution Control Costs	4-110
<u>Appendix</u>		<u>Page</u>
A	The SEAS System: A brief Description	A-1
B	Scenarion Assumptions	B-1
C	Impact of Increases Federal Grants for Municipal Wastewater Treatment	C-1
D	Estimating the Cost for Industries to Control Pollution	D-1

Section Four

A COMPREHENSIVE ASSESSMENT OF POLLUTION CONTROL IMPACT MEASUREMENT UNDER ALTERNATIVE FUTURES

This Section presents estimates at national and industrial levels of the key economic, environmental, and energy impacts of Federal pollution controls and regulations. These impacts are examined under different sets of basic assumptions about economic activity levels and energy conservation policies and programs. The period of 1971 through 198⁵ was evaluated since it includes the time frame in which the legislated environmental policies were put into effect. This analysis is conducted by running alternative scenarios, using a computerized, impact estimation and analysis system, the Strategic Environmental Assessment System (SEAS).

The magnitude and interrelationships of the estimated impacts are conditionally forecast based upon the assumptions made explicit in each scenario. The basic structure of the economy, and the fiscal policies which help guide it, are taken as given in any specific run of the model system. These basic assumptions are what constitute a specific scenario. Before describing the scenarios and

their analysis, it is useful to place the national projections, using SEAS, into perspective.

\$aChapter 1

Impact Estimation Using

The Strategic Environmental

Assessment System (SEAS)\$R

On several previous occasions, there have been estimates made of the projected impacts on the national economy of pollution abatement programs. The Environmental Protection Agency (e.g., see The Economics of Clean Water-1973 and The Economic Impact of the Federal Environmental Program-1974, the Council on Environmental Quality (Annual Reports), the U. S. Congress Joint Economic Committee, and other agencies have utilized a variety of economic models to project impacts upon overall price levels and levels of economic activity. These have included procedures developed either by the agencies themselves or by private groups, such as Chase Econometrics Associates, the Brookings Institution, and Data Resources Incorporated.

For the most part, this previous work has led to forecasts that the inflationary influences of pollution abatement programs would be comparatively minor relative to the totality of inflationary influences, and the effects on national income would also be relatively minor. In addition, several previous studies of pollution abatement

Impacts have devoted considerable attention to evaluating the benefits and costs flowing from pollution abatement programs. The purpose of such benefit/cost analyses has been to assess whether the nation would receive environmental benefits greater than the expenditures proposed for achieving them.

The current work described in this Section departs from these previous efforts in three important ways:

- First, no attempt is made to develop a single set of impact projections; rather, impacts are measured conditionally based upon different sets of general socioeconomic assumptions of future additions;
- Second, the analysis focuses on how these impacts are differentially affected by the various basic assumptions of future economic activity and energy policy, rather than their absolute levels (although these are also presented);
- Third, control costs and resultant pollution estimates are developed at a greater level of industrial detail with the effect of economic feedbacks by sector are included. (Feedbacks are purchases made for pollution

control equipment and operations that stimulate output in sectors that produce such items.)

The present imprecise state of knowledge regarding the evaluation of future benefits makes any attempt to compile a national aggregate figure for benefits subject to large uncertainties. As a substitute approach, consequences of pollution abatement programs are analyzed through tradeoffs between the various costs and impacts of achieving legislated Federal control objectives.

The general procedure used for tradeoff analysis is as follows:

1. Select a consistent set of general economic, environmental, demographic and resource-energy assumptions;
2. Calculate a set of forecasts of the economy, industry output, environmental residuals and energy budgets given that specific industry environmental controls are not increased beyond those present in 1971.
3. Calculate the same forecasts, given that environmental controls, costs and equipment purchases are

superimposed on the other economic structures as necessary to comply with Federal pollution control legislation.

4. Compare the differences in output information relative to the levels of the non-abatement case for national level statistics and for industry-detailed statistics.

This procedure was performed for three alternative sets of assumptions, plus two variations on environmental controls and costs. Steps 1 and 3 above draw on the data provided in Sections Two and Three of this report. The forecasts required in Steps 2 and 3 are derived from operation of SEAS using these data. Step 4, the impact analysis, is a quantitative investigation of the SEAS simulation results to determine levels of environmental pollution, pollution control costs, and economic and resource usage statistics. (See Appendix A for a brief description of the SEAS system as used for this application.)

Chapter 2

Scenario Assumptions

Six major scenarios were constructed to develop impact estimates through 1985 under alternative sets of assumptions about the future. The scenarios are divided into three pairs, in which each pair represents a predefined "case" of future economic and energy-consumption conditions. The three cases selected for this study are a Reference Case, a Low Productivity Case, and an Energy Conservation Case.

A "non-abatement" scenario and an "abatement" or "compliance" scenario were run to provide the two alternative forecasts for each case. Each forecast provides annual projections through 1985 of major macroeconomic and demographic variables, industrial outputs, energy usage, domestic demand for virgin stocks, recycling levels, transportation demand, and environmental pollution levels. The first, or non-abatement scenario, estimates the value of these variables which would have occurred in the absence of Federal pollution control legislation. It assumes that no incremental expenditures are made by industries, utilities, and municipalities to improve pollution control beyond that in effect in 1971, and that all new industrial facilities will control pollution to the same extent as that

practiced in 1971. It also assumes that Federal expenditures do not include any additional subsidies for pollution control past 1971. The non-abatement scenario, however, does allow for pollution reductions resulting from process substitutions which would likely have occurred without Federal legislation.

The second or abatement scenario in each case assumes that sufficient abatement expenditures are made to bring air and water pollution from industry, utility, municipal, and mobile sources into full compliance with Federal statutes. It also provides for additional Federal expenditures to cover the cost of pollution abatement at Federal plants and the cost of other Federally-sponsored pollution control programs. The abatement scenarios provide estimates of the incremental costs of pollution control through 1985, as well as estimates of the variables forecast in the non-abatement scenarios.

The six scenarios are summarized below:

Case	Non-Abatement Scenarios (Without Incremental Control Costs)	Compliance Scenarios (With Incremental Control Costs)
Reference	Scenario 1	Scenario 2
Low Productivity	Scenario 3	Scenario 4
Energy Conservation	Scenario 5	Scenario 6

The following names are used in the remainder of this
Section to identify each scenario:

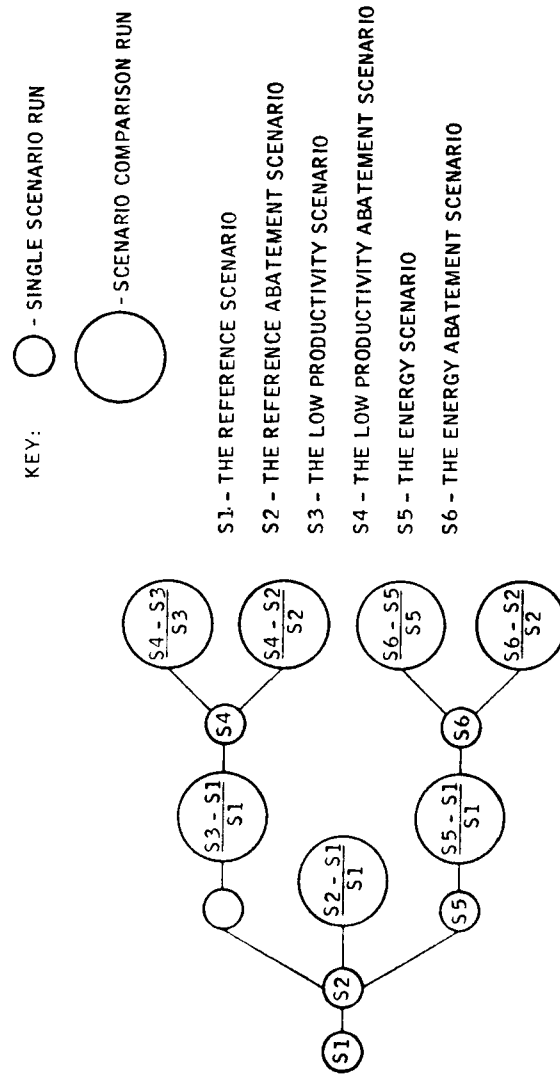
- Scenario 1 - The Reference Scenario
- Scenario 2 - The Reference Abatement Scenario
- Scenario 3 - The Low Productivity Scenario
- Scenario 4 - The Low Productivity Abatement Scenario
- Scenario 5 - The Energy Scenario
- Scenario 6 - The Energy Abatement Scenario

The six scenarios were produced in the sequence shown in
Figure 1. This sequence is designed to permit a comparative
analysis of the relative impacts and tradeoffs between

logical scenario pairs. Certain pairs are compared to analyze the consequences of pollution control under the conditions assumed for each case: (1.2) (3.4) and (5.6). Other pairs provide an analysis of the impacts of the assumptions themselves, both in the absence of incremental abatement costs: (1.3) and (1.5); and with these costs applied: (2.4) and (2.6).

Figure 1.
Scenario Run Sequence

| 169
| 170



The objective in comparing the economic, environmental, and energy consequences of two scenarios is not to claim that one is better or more realistic than the other, but to develop an analysis that will provide meaningful abatement cost forecasts. Examples of the kind of analysis afforded by contrasting scenario pairs is presented below:

- The Reference Case vs. The Low Productivity Case - The two Reference Case scenarios call for the U.S. economy to approach full employment in the early 1980's along a relatively high productivity, high growth supply-oriented path. The alternative Low Productivity scenarios reflect a lower productivity and growth profile. By comparing first the Low Productivity Scenario with the Reference Scenario, and then the Low Productivity Abatement Scenario with both the Low Productivity Scenario and the Reference Abatement Scenario, one can analyze the economic, environmental, and energy consequences of implementing pollution controls with and without high-productivity conditions. Such an analysis affords insights into the differences in abatement cost impacts arising from two comparatively realistic, but potentially very different economic futures.

- The Reference Case vs. The Energy Conservation Case -
The Reference Case scenarios contain a number of basic energy conservation policy measures. The Alternative Energy Conservation Case scenarios provide for an even more rigorous set of energy conservation policies and programs. A comparison of the Energy Scenario with the Reference Scenario, followed by comparisons of the Energy Abatement Scenario with the Energy Scenario and the Reference Abatement Scenario, affords an understanding of the differences in the potential economic, environmental, and energy consequences of legislated pollution controls under a range of energy consumption assumptions.

The assumptions used to construct the Reference and Reference Abatement Scenarios are presented in Appendix B.

5aChapter 3
Macro-Analysis Results\$R

Results from the six SEAS scenario runs were subjected to both macro- and sector-level analyses of the estimated economic, environmental, and energy consequences of pollution control. The following discussion presents the macro-level findings, beginning with the Reference Scenario and proceeding through the selected scenarios and scenario comparisons. Appendix C presents an analysis of a variant of the Reference Abatement Scenario, which assumes a continuing appropriation of \$7 billion a year for municipal sewage treatment facilities.

A summary of the major results from the SEAS scenarios is presented in Table 1. These results show that, over the decade 1976-85, the total cost of complying with Federal air and water pollution control legislation constitutes a relatively small portion of the decade's accumulative gross national product. Total decade abatement costs, as a percentage of GNP, range from 2.41 percent for the Energy Conservation Case to 2.60 percent for the Reference Case variant scenario where the municipal sewage appropriation is set at \$7 billion per year over the decade.

Table 1 reflects a fairly constant increase in energy use by 1985 of 3.7 to 3.9 quadrillion Btu's resulting from the addition of incremental abatement practices in each of the three cases. It also shows the reduction in net residuals achieved by 1985 as a percentage of the Reference Scenario forecasts for each of four major air and water pollutants, respectively. In general, the greatest abatement is attained in the Low Productivity Case, except for the lower amounts of biochemical oxygen demand (BOD), suspended solids, and nutrients achieved in the \$7 billion per year municipal scenario.

The annual composition of pertinent data on the economy, energy use, resource demand, pollutant residuals, and abatement costs are presented in the discussions which follow.

\$t
Table 1.
Summary of Scenario Results

Scenario	Decade GNP (Trillion 1975\$)	Decade Pollution Control Cost (% GNP)	1985 Energy Consumption (Quad. Btu's)	SO	Part	NO	HC	CO	BOD	SS	(% of Reference)	Nut.
Reference	20.007	0.0	109.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Reference Abatement	20.162	2.42	112.9	37.9	12.6	91.3	39.3	26.5	16.9	9.3	61.4	44.1
Reference Abatement with \$7 B/yr Municipal Appropriation	20.195	2.60	113.2	38.0	12.7	91.6	39.3	26.5	14.5	7.9	61.4	27.4
Low Productivity	18.596	0.0	102.0	90.3	90.6	88.5	87.3	84.9	93.2	91.9	88.5	99.3
Low Productivity Abatement	18.849	2.53	105.7	34.1	11.3	81.5	35.1	23.0	15.7	8.7	54.3	43.8
Energy Conservation	20.062	0.0	95.7	89.9	93.9	91.8	86.3	86.8	99.3	99.4	96.7	99.9
Energy Conservation Abatement	20.201	2.41	99.6	34.6	11.9	84.5	34.8	24.4	16.9	9.2	58.6	44.2

1. See Tables 2, 4, 9, 12, 17, 21, and C-1, for composition of pollution control costs by year from 1976 through 1985.

2. Part = Particulates, SS = Suspended Solids, DS = Dissolved Solids, Nut. = Nutrients, SO = Sulfur Oxides, NO = Nitrogen Oxides.\$R

\$bTHE REFERENCE SCENARIO\$R

The Reference Scenario, which provides the baseline for all subsequent projections, includes the general forecast conditions described below. (See Appendix B for a detailed discussion of these assumptions.)

1. High productivity and government policy to achieve a full-supply labor force economy by the mid-1980s will produce a 1985 GNP of \$2.36 trillion (1975 constant) with an unemployment rate of 4.4 percent for a projected labor force of 107.7 million civilian workers.
2. No municipal or industrial process will increase its environmental control activities above the treatment efficiency levels in practice at the end of 1971.
3. Energy usage and conservation will be consistent with energy forecasts of the \$7.00/barrel "Business-as-Usual Without Conservation" scenario of Project Independence, an aggregate requirement of 109 quadrillion Btu's in 1985.

Based on these assumptions, the Reference Scenario forecast was projected for the decade 1976-85, and 1985. Some

general statistics that characterize the baseline projections appear in Table 2.

The picture of the national economy against which pollution control was cast was one in which the country will gradually grow out of the present recession to achieve an unemployment rate of 4.4 percent by 1985. The assumed growth rate in GNP was 6.5 percent between the years 1975-80 and somewhat slower between 1981-85 (4.0 percent).

Over the decade, the personal consumption expenditures and equipment investment components of the GNP showed greater growth rates than the overall GNP growth rate. Non-Federal government expenditures increased at rates well ahead of increases in exogenously set Federal expenditures levels (4.4 percent annual increase to 1.6 percent).

Total national industrial output grew at a rate somewhat greater than GNP with the sectors of agriculture and mining showing the slowest rates of growth, manufacturing output growing slightly less than overall output, and the sectors of services, transportation, communication and electric utilities exhibiting the greatest growth.

The slowdown in the growth rate in the years 1980-85 as the country catches up from the downturn of the early 50-enties is also reflected in most of the other growth rate changes.

The energy requirement to support this economic pattern reflects a growing use of electricity by the final consumers. By 1985, coal and nuclear sources will account for 53 percent of all electrical generation, with coal accounting for 33 percent. Growth in total natural gas, petroleum and coal usage on an annual rate basis over the decade will be 1.1 percent, 2.8 percent and 3.8 percent, respectively.

Table 2.
General Projections of the Reference Scenarios (\$1).
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	221.90	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	7.90	7.10	6.00	5.50	5.10	5.30	4.80	4.60	4.50	4.40
Disposable Income Per Capita (1,000 1975 \$)	5.62	5.99	6.61	7.04	7.54	7.73	8.07	8.31	8.55	8.78
Gross National Product (Trillion 1975 \$)	1.56	1.67	1.77	1.89	2.01	2.08	2.15	2.22	2.29	2.36
Personal Consumption Expenditure	0.97	1.02	1.12	1.19	1.28	1.32	1.39	1.46	1.51	1.56
Investment	0.26	0.29	0.29	0.32	0.34	0.35	0.36	0.36	0.37	0.38
Government Expenditures	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41
Federal	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14
Other	0.20	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27
Total Output (Trillion 1975 \$)	2.61	2.80	2.98	3.19	3.41	3.53	3.67	3.80	3.93	4.07
Manufacturing	1.10	1.18	1.25	1.33	1.42	1.46	1.50	1.54	1.59	1.63
Total Energy Use (Quadrillion Btu's)	79.97	83.48	86.63	90.12	93.62	96.40	99.40	102.50	105.68	109.01
Natural Gas	19.06	18.96	19.43	19.92	20.43	20.59	20.83	21.05	21.26	21.47
Petroleum	31.36	32.38	33.40	34.52	35.58	36.52	37.43	38.37	39.28	40.19
Coal	4.59	4.89	5.01	5.28	5.55	5.67	5.80	5.94	6.08	6.24
Electricity	24.95	27.26	28.78	30.40	32.06	33.61	35.33	37.14	39.06	41.11
U.S. Demand (Million Metric Tons)										
Copper	2.35	2.61	2.75	2.89	3.03	3.08	3.14	3.21	3.29	3.36
Iron	141.60	150.34	148.75	158.03	166.43	167.01	166.89	167.98	169.50	171.43
Aluminum	4.72	5.13	5.36	5.76	6.17	6.36	6.53	6.73	6.94	7.17
Recycled Materials (Million Metric Tons)										
Paper	68.80	72.91	76.03	80.02	84.33	86.77	89.54	92.27	94.81	97.10
Aluminum	6.22	6.66	7.20	7.71	8.25	8.54	8.90	9.23	9.56	9.89
Ferrous Metals	1.20	1.51	1.55	1.69	1.89	2.05	2.08	2.17	2.31	2.37
	41.50	43.70	44.87	46.73	48.71	49.96	51.30	52.63	53.67	54.54

Table 2. (Continued)
General Projections of the Reference Scenarios (\$t).
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Vehicle Kilometers (Trillions) Auto	1.62 1.61	1.70 1.68	1.85 1.83	1.94 1.92	2.05 2.03	2.11 2.09	2.21 2.19	2.28 2.26	2.35 2.33	2.42 2.40
Total Freight Metric Ton- Kilometers (Billions) Truck	3.55 0.73	3.76 0.79	3.92 0.83	4.14 0.89	4.35 0.95	4.49 1.00	4.64 1.04	4.80 1.09	4.96 1.14	5.10 1.20
Rail	1.14	1.21	1.25	1.31	1.37	1.41	1.45	1.49	1.53	1.57
Net Air Residuals (Million Metric Tons)										
Particulates	38.02	40.55	42.32	44.55	46.81	47.72	48.73	49.89	51.08	52.34
Sulfur Oxides	37.20	40.40	41.60	43.10	44.70	45.30	46.00	46.90	47.90	49.10
Nitrogen Oxides	18.60	20.00	21.00	22.10	23.20	23.80	24.60	25.40	26.20	27.20
Hydrocarbons	12.20	12.40	13.00	13.40	14.00	14.20	14.70	15.10	15.50	15.90
Carbon Monoxide	72.30	76.40	82.20	86.90	92.30	95.20	99.60	103.00	106.40	109.80
Net Water Residuals (Million Metric Tons)										
Biochemical Oxygen Demand	5.00	5.20	5.40	5.70	5.90	6.00	6.10	6.30	6.50	6.60
Suspended Solids	11.79	12.34	12.79	13.38	13.98	14.20	14.45	14.71	14.97	15.24
Dissolved Solids	12.20	12.70	13.30	13.90	14.40	14.50	14.70	14.80	15.00	15.20
Nutrients	1.60	1.60	1.60	1.70	1.70	1.70	1.70	1.70	1.70	1.80
Direct Costs										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs										
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0

Table 2. (Continued)
General Projections of the Reference Scenarios (S1).
1976-1985

\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Water Industrial Costs										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0
Municipal Costs										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$s\$R

Demand projections provide an indication of the increasing requirements for natural resources. For example, U.S. demand for iron ore increases at an annual rate of 3 percent per year over the period, with most of the increase occurring in the 1970 decade. Similar demand patterns are noted for both aluminum and copper. This usage reflects the output growth patterns shown in Table 2 for both total and manufacturing output, in which the annual growth rates of the late 1970's are twice or more than the rates for the early 1980's. The patterns noted for ores are also found in the recycling statistics for paper/paperboard, aluminum and ferrous metals.

As a final set of characterizations of the Reference Scenario, the following patterns are noted for annual levels of air and water environmental residuals.

First, the annual growth rates of all air- and water-borne residuals are less than the economic growth rate and are less than the manufacturing output growth rate. Thus, even with no additional controls past 1971, relative improvements of residuals per dollar of output are noted for all major residuals categories due to improved production technology. However, the relative change is small, and the absolute levels of annual residual loads are increasing for all air and water residual categories.

The projections also show that air residuals are increasing at rates greater than the water residuals. To provide greater detail on growth rates by generation source, Figures 1 and 2 are provided for evaluation comparison.

The data in Figures 1 and 2 demonstrate that, although the growth rates of air residuals connected with mobile sources is greater than those for stationary sources, the growth rate of air residuals from any source is consistently higher than the growth rate of water residuals.

As a final comparison of residual generation patterns within the Reference Scenario projections, Table 3 contrasts the rates of change of air and water residuals due to industrial sources for two categories:

- Gross Residuals - The residuals that would occur if there were no end-of-process treatment of discharges.
- Net Residuals - The residuals that occur due to end-of-process treatment of discharges using in-practice 1971 technologies for each industrial process.

157

158

Figure 1.

Trends in Air Pollutants from Reference Scenario

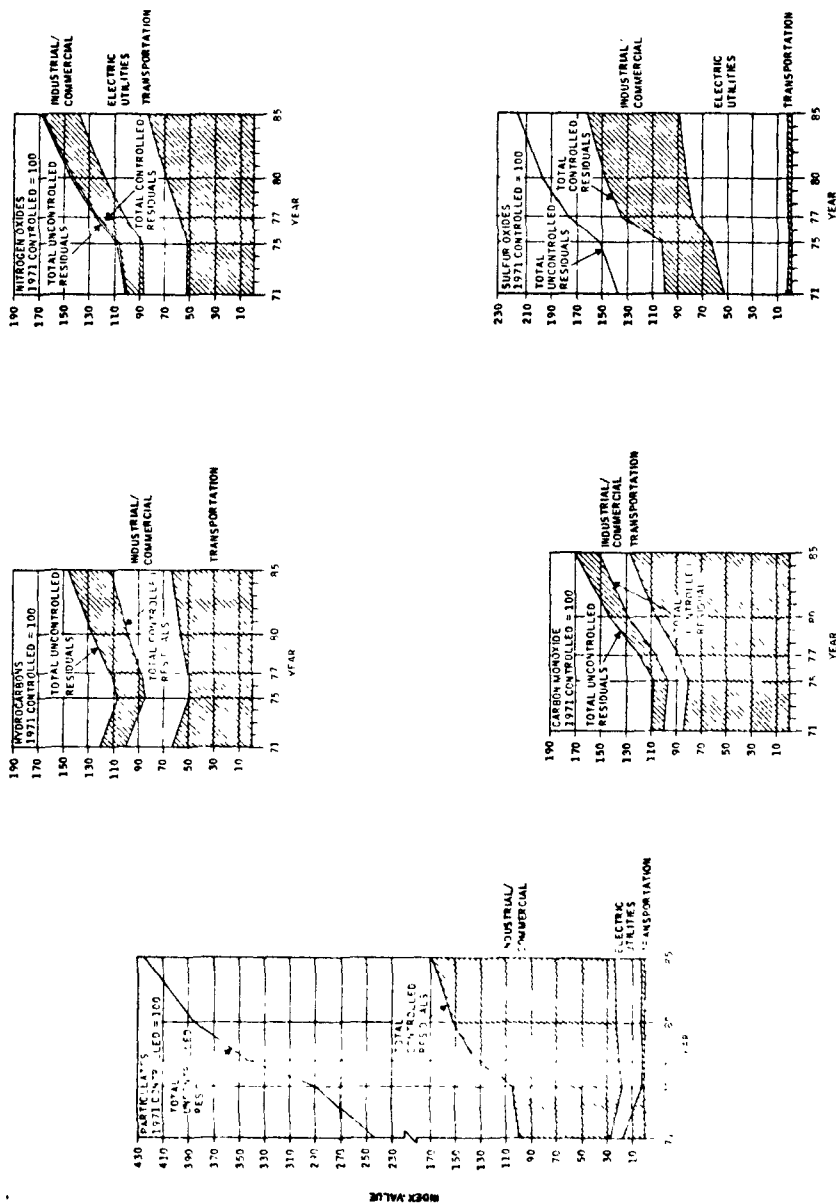


Figure 2.

1971 Water Residuals from Balance Scenario

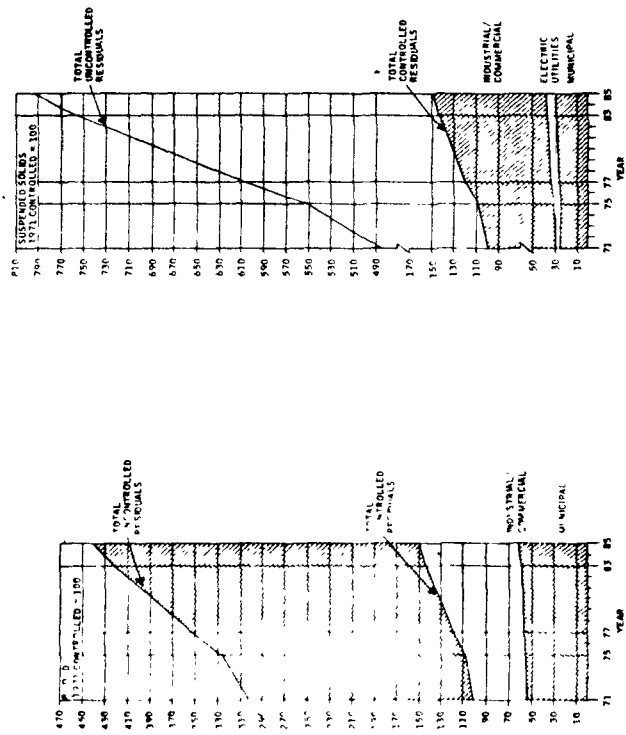
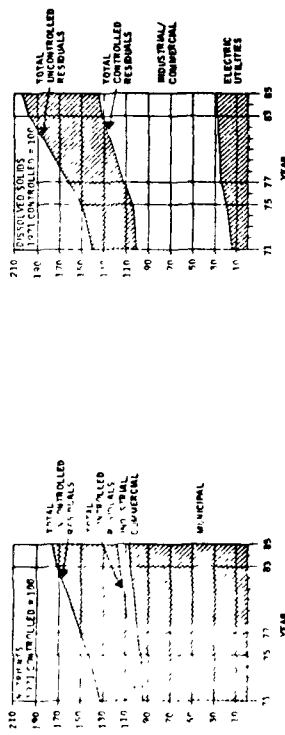


Table 3.
Aggregate Removal Percentages in
Selected Years for the
Reference Scenario

\$t	1975	1980	1985
Air Residuals			
Particulates	60.76	61.07	60.96
Sulfur Oxides	25.56	25.10	25.53
Nitrogen Oxides	0.22	0.23	0.25
Hydrocarbons	39.70	39.70	41.45
Carbon Monoxide	42.22	41.24	41.66
Water Residuals			
Biochemical Oxygen Demand	66.82	66.26	66.20
Suspended Solids	80.21	80.70	81.36
Dissolved Solids	30.98	32.20	34.25
Nutrients	27.53	31.63	34.13\$R

In the case of the air residuals, the gross and net residual growth rates are similar, suggesting only minor improvements in industrial processes in the abatement of air emissions. On the other hand, the net water residuals exhibit smaller growth rates compared with the values for gross water residuals (with the exception of BOD). This suggests that industrial sectors which had higher efficiency treatment processes as of 1971 are growing faster than the more polluting sectors.

In summary, the Reference Scenario forecasts react as would be expected with the calibration of the macroeconomic indicators to a high-growth, high-productivity set of

assumptions. Economic growth and resource usage are greatest in the period 1975-80, with all annual growth rates considerably slowed in 1980-85. Environmental residuals for the major categories are increasing, but the annual growth rates are less than the annual economic growth rates. Between air and water residuals, the air residuals consistently show the greater growth rate.

\$B
COMPARISON OF THE REFERENCE SCENARIO
WITH AND WITHOUT ABATEMENT EFFECTS\$R

The Reference Scenario assumptions were changed in the following ways to provide a scenario that approximated the Reference Scenario, but which also included the effects and costs of Federal air and water pollution control regulations:

1. All required treatment efficiencies and associated cost functions for each process were introduced into the calculations.

2. All capital and O&M costs as forecast annually were fed back into the economy as increased interindustry purchase and labor requirements.

3. The additional labor force required for pollution control was assumed to be met by reducing unemployment until the commonly accepted minimum level of 4 percent was reached.

This new scenario, the Reference Abatement Scenario, is compared to the Reference Scenario in the analysis that follows.

The schedule of compliance with Federal regulations causes some of the capital expenditures for pollution control devices to occur as early as 1971; hence the 1975 data between the two scenarios exhibit considerable differences. Table 4 is comparable to Table 2, which was presented for the Reference Scenario. The values of the various statistics for the years 1975 and 1985 provide a useful context for comparing the relative growth rates. Note that the costs and additional industrial output associated with compliance in the Reference Abatement Scenario acted as a stimulus to GNP, total output and employment.

In the period 1975-79, there was sufficiently high unemployment that the additional resources required to carry out the mandated abatement activities could be absorbed out of idle resources, thus resulting in a net benefit to the economy. From 1980-85 however, the required level of resource uses for abatement control was in excess of the amount available, and so resources had to come from other sources. Even in these cases, the fact that there were some unemployed resources before abatement controls were mandated meant that the GNP increased in all years. Among the industries that are required to implement abatement technologies, the efforts vary from those that, although they are required to shift revenues away from production to pollution control, receive enough orders to build the devices to offset or more than offset the shift. Other industries are net gainers (platinum), and still others are net losers (agriculture). The sector that absorbs almost all the expenditure shifts is the consumer.

Table 4.
General Projections of the Reference Abatement Scenario (\$2),
1976-1985

\$t Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	221.90	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	6.20	5.20	4.20	4.30	4.70	4.60	4.50	4.30	4.10	4.10
Disposable Income Per Capita (1,000 1975 \$)	5.62	5.99	6.61	7.02	7.47	7.72	8.01	8.23	8.52	8.73
Gross National Product (Trillion 1975 \$)	1.59	1.69	1.81	1.91	2.02	2.09	2.16	2.23	2.30	2.37
Personal Consumption Expenditure	0.97	1.03	1.12	1.19	1.27	1.33	1.39	1.45	1.50	1.56
Investment	0.28	0.30	0.31	0.33	0.35	0.36	0.36	0.37	0.37	0.38
Government Expenditures	0.32	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42
Federal	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14
Other	0.20	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28
Total Output (Trillion 1975 \$)	2.67	2.86	3.02	3.25	3.44	3.56	3.69	3.82	3.95	4.11
Manufacturing	1.13	1.21	1.28	1.36	1.44	1.48	1.51	1.55	1.59	1.64
Total Energy Use (Quadrillion Btu's)	83.11	86.84	90.19	93.58	96.75	99.73	102.65	105.85	109.43	112.89
Natural Gas	19.65	19.60	20.09	20.57	20.98	21.21	21.41	21.64	21.96	22.18
Petroleum	32.86	33.79	34.76	35.76	36.63	37.57	38.42	39.32	40.26	41.15
Coal	4.81	5.13	5.28	5.48	5.66	5.79	5.89	6.02	6.16	6.21
Electricity	25.80	28.32	30.06	31.77	33.47	35.17	36.95	38.87	40.05	43.25
U.S. Demand (Million Metric Tons)										
Copper	2.46	2.73	2.86	2.99	3.10	3.14	3.19	3.25	3.31	3.38
Iron	147.96	157.50	157.63	163.78	168.30	168.97	167.75	168.06	169.05	170.93
Aluminum	4.87	5.31	5.53	5.89	6.22	6.41	6.56	6.74	6.94	7.16
Recycled Materials (Million Metric Tons)										
Paper	69.76	73.96	76.59	80.83	84.53	87.15	89.69	92.48	95.11	97.44
Aluminum	6.26	6.71	7.25	7.73	8.22	8.45	8.87	9.22	9.56	9.88
Ferrous Metals	1.39	1.55	1.59	1.72	1.90	2.07	2.09	2.18	2.31	2.37
	42.20	44.42	45.80	47.35	48.98	50.24	51.51	52.87	53.98	54.95

Table 4. (Continued)
General Projections of the Reference Abatement Scenario (S2),
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Vehicle Kilometer (Trillions)										
Auto	1.62	1.70	1.83	1.93	2.03	2.11	2.19	2.27	2.34	2.41
Truck	1.61	1.68	1.81	1.91	2.01	2.09	2.17	2.25	2.32	2.39
Total Freight Metric Ton-Kilometer										
(Billions)	3.67	3.89	4.06	4.25	4.43	4.58	4.72	4.87	5.04	5.21
Truck	0.75	0.81	0.86	0.92	0.97	1.01	1.06	1.11	1.16	1.22
Rail	1.18	1.25	1.30	1.35	1.39	1.43	1.47	1.51	1.55	1.60
Net Air Residuals (Million Metric Tons)										
Particulates	15.70	9.41	9.55	9.90	10.23	10.42	9.60	8.78	7.92	7.05
Sulfur Oxides	19.47	14.68	15.35	16.01	16.65	17.06	17.35	17.72	18.17	18.62
Nitrogen Oxides	18.62	19.85	20.80	21.49	22.17	22.58	23.20	23.76	24.25	24.79
Hydrocarbons	10.11	9.52	9.45	9.16	8.91	8.57	7.98	7.35	6.83	6.27
Carbon Monoxide	58.17	55.20	53.53	50.39	47.30	43.33	38.69	35.27	31.62	29.08
Net Water Residuals (Million Metric Tons)										
Biochemical Oxygen Demand	2.94	2.10	1.65	1.68	1.71	1.58	1.44	1.29	1.14	1.12
Suspended Solids	7.07	4.67	2.70	2.70	2.76	2.41	2.04	1.64	1.23	1.19
Dissolved Solids	11.58	11.56	11.57	11.96	12.32	11.38	10.50	9.71	9.03	9.31
Nutrients	1.33	1.24	1.18	1.13	1.07	1.02	0.96	0.90	0.84	0.78
Air Control Costs (Billion 1975 \$)										
Investment	9.19	11.88	17.47	15.16	13.58	13.36	13.08	12.96	12.99	13.22
Annualized Costs										
Capital	9.47	11.43	14.99	17.95	20.39	22.53	24.36	25.90	27.17	28.20
O&M	9.60	9.42	9.26	9.58	9.73	9.70	9.58	9.42	9.30	9.19
Capital in Place	43.27	51.82	64.62	74.29	81.55	87.81	93.02	97.33	100.09	103.94
Direct Employment (Thousands)	14	17	19	21	21	21	21	21	20	20

Table 4. (Continued)
General Projections of the Reference Abatement Scenario (\$2).
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Water Industrial Cost (Billion 1975 \$)										
Investment	5.11	7.31	4.85	6.82	7.85	7.22	6.85	5.37	1.42	1.72
Annualized Costs										
Capital	2.19	3.11	3.70	4.54	5.52	6.41	7.31	8.00	8.17	8.38
O&M	3.69	4.89	5.93	6.43	6.86	7.21	7.46	7.78	11.01	11.46
Capital in Place	17.03	24.34	29.13	35.88	43.67	50.83	57.61	62.92	64.20	65.78
Direct Employment	116	153	187	203	219	231	240	252	371	387
(Thousands)										
Water Municipal Costs (Billion 1975 \$)										
Investment	6.55	8.11	8.13	5.59	2.94	1.77	0.80	0.70	0.70	0.53
Annualized Costs										
Capital	2.27	3.17	4.06	4.68	5.00	5.20	5.28	5.36	5.44	5.50
O&M	0.68	0.93	1.36	1.61	1.76	1.84	1.89	1.93	1.97	2.00
Capital in Place	20.63	28.74	36.88	42.47	45.41	47.17	47.97	48.67	49.37	49.90
Direct Employment	20	27	40	48	52	54	56	57	58	59
(Thousands)										

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$s\$R

Table 5 provides a comparison of a number of scenario statistics with the same values developed in the Reference Scenario for each of the five snapshot years. (The comparison uses the Reference Scenario as a base, i.e. (S2-S1)/S1.) Table 6 presents pollution control costs throughout the decade relative to GNP.

When looked at in comparative terms, the costs of pollution control are seemingly minimal. In GNP terms, as noted earlier, the output of total goods and services increased throughout the decade. Consequently, the introduction of these controls (given the assumptions stated) is equally favorable also for all of the factors of final demand. Further, the change in production processes and the shift in the mix of goods and services produced resulted eventually in a lesser requirement for some of our natural resources, paper and iron being a noticeable example by 1985, although during the phase of new capital development, these same resources (and others) actually were used at higher rates. Finally, this positive boost to the economy results in the reduction of air and water residuals. Apparently, this will be a very worthwhile shift in the expenditure portions of the nation.

\$Table 5.
Comparison of the Macro-Statistics of the Reference
Abatement Scenario (S2) and the Reference Scenario (S1)
[(S2-S1)/S1 in %]

Statistic	1975	1977	1980	1983	1985
Gross National Product	2.06	1.92	0.41	0.24	0.08
Disposable Income Per Capita	0	0	-0.95	-0.43	-0.50
Federal Expenditures	0.24	1.06	2.25	2.19	2.16
Personal Consumption Expenditures	0.57	0.36	-0.49	-0.27	-0.29
Total Output	2.46	2.32	0.72	0.49	0.39
Manufacturing	3.15	2.85	1.03	0.63	0.45
Investment	7.93	6.12	2.75	1.21	0.42
Energy Use	4.23	4.01	3.38	3.27	3.56
Demand: Iron	5.35	4.76	1.12	0.05	-0.29
Aluminum	3.73	3.34	0.91	0.20	-0.13
Recycling:					
Paper	0.67	0.75	-0.36	-0.11	-0.10
Aluminum	2.16	2.65	0.50	0.46	0.00
Ferrous Metals	1.78	1.64	0.55	0.45	0.75
Vehicle Kilometers	0.00	0.00	-0.98	-0.44	-0.41
Freight Ton-Kilometers	3.70	3.48	1.85	1.52	1.52
Net Air Residuals					
Particulates	-42.63	-80.98	-81.83	-84.42	-87.43
Sulfur Oxides	-32.72	-63.63	-62.78	-62.22	-62.11
Nitrogen Oxides	0.23	-0.72	-4.34	-6.40	-8.72
Hydrocarbons	-13.33	-23.31	-36.33	-51.39	-60.67
Carbon Monoxides	-18.14	-27.72	-48.73	-65.76	-73.52
Net Water Residuals:					
Biochemical Oxygen Demand	-22.40	-59.68	-71.07	-79.52	-83.09
Suspended Solids	-17.74	-60.52	-78.63	-87.32	-90.68
Dissolved Solids	-0.90	-9.13	-14.54	-34.71	-38.65
Nutrients	-9.94	-22.59	-35.66	-47.91	-55.86

Table 6.
Pollution Control Costs in Selected Years
as a Percentage of Reference Scenario GNP
\$t

	1977	1980	1983	1985	1976-85
Air Stationary Source Costs					
Capital Cost	0.33	0.09	0.03	0.03	0.12
O&M Cost	0.24	0.26	0.24	0.23	0.25
Water Industrial Costs					
Capital Cost	0.42	0.41	0.24	0.06	0.27
O&M Cost	0.29	0.34	0.35	0.48	0.36
Water Municipal Costs					
Capital Cost	0.49	0.15	0.03	0.02	0.17
O&M Cost	0.06	0.09	0.09	0.08	0.08

The effects on environmental residuals are generally substantial, but quite different patterns and relative efficiencies emerge when compared with the 1971 control technologies. For example, the air residuals, Table 7, show this comparison.

\$dTable 7.
Aggregate Stationary Source Removal Percentages in
Selected Years for the Reference and Reference Abatement Scenarios

	1975		1980		1985	
	Reference	Reference Abatement	Reference	Reference Abatement	Reference	Reference Abatement
Air Residuals						
Particulates	60.76	77.44	61.07	92.45	60.96	95.25
Sulfur Oxides	25.56	52.53	25.10	73.88	25.33	73.28
Nitrogen Oxides	0.22	2.53	0.23	5.65	0.25	5.65
Hydrocarbons	39.70	50.84	39.70	59.30	41.45	70.79
Carbon Monoxide	42.22	56.11	41.24	64.06	41.66	65.90
Water Residuals						
Biochemical Oxygen Demand	66.82	74.40	66.26	90.23	66.20	94.28
Suspended Solids	80.21	84.42	80.70	96.11	81.36	98.36
Dissolved Solids	30.98	33.84	32.20	44.36	34.25	61.56
Nutrients	27.53	35.23	31.63	56.82	34.13	71.71

- For particulates and sulfur oxides, the level of maximum efficiency is generally realized by 1980 with minor changes after that time. Since the primary emitters are stationary sources and the existing plants are assumed fully-regulated by 1980, the time pattern is expected. Small further improvement can be noted due to the more stringent regulations on new facilities.

- For nitrogen oxides, the relative levels of treatment are so minimal that the level of annual residuals from industries increases at nine-tenths the rate of

economic output. About 60 percent of all nitrogen oxide residuals are caused by stationary sources. For vehicle emissions, the rate of improvement is somewhat better, but still so marginal that an increase in annual levels of total nitrogen oxides released to the air is noted. Table 8 provides data for nitrogen oxide from mobile sources, showing a 22 percent reduction in emissions per kilometer in 1985.

For the final two air residual categories, hydrocarbons and carbon monoxide, significant improvements by 1985 are noted (69 and 85 percent relative reductions respectively, as shown in Table 8). This effect, unlike that seen for particulates, is because the chief emitters are mobile sources of considerable vintage. Since retrofit equipment is not hypothesized here, the steady state condition of all autos having emission characteristics similar to the most stringent standards will not occur until about 1995 when most of the 1970- and-earlier vintage cars will have been retired. Thus, delays in meeting specific mobile source standards can be reflected in higher annual emissions for periods up to two decades later.

\$dTable 8.
Transportation Emissions Levels for the Reference
and Reference Abatement Scenarios
(Metric Tons per Million Vehicle Kilometers Travelled)

	1975		1980		1985	
	Reference	Reference Abatement	Reference	Reference Abatement	Reference	Reference Abatement
Particulates	0.46	0.43	0.51	0.43	0.54	0.42
Sulfur Oxides	0.36	0.36	0.37	0.39	0.40	0.40
Nitrogen Oxides	5.23	5.12	5.34	5.07	5.66	4.42
Hydrocarbons	4.45	3.87	3.74	2.30	3.73	1.15
Carbon Monoxide	36.21	29.72	36.38	18.50	37.95	7.62

The water residuals, as shown in Table 7, exhibit the following patterns:

- For BOD and total suspended solids, significant improvement occurs throughout the decade, with high points coinciding with the regulatory years for BPT and BAT. Since most suspended solids are treated within industrial plants, the required high-efficiency level is reflected in a relative removal level of 91 percent. The pre-1971 BOD removal requirements at municipal plants are reflected in an improvement of only 83 percent. The actual removal efficiency achieved by 1985 is 94 percent of the BOD and 98.4 percent of the suspended solids that would have occurred if no treatment took place.

- For total dissolved solids, the Federal controls produce some relative improvements by 1977, the GPT Year, and then almost double in relative improvement by 1985. Even in 1985, however, the actual removal efficiency is only about 62 percent.
- For nutrients, the relative efficiencies of treatment improve from an efficiency of about one-third in 1975 to 72 percent in 1985.

Thus, it appears that the Reference Abatement Scenario has positive benefits over the Reference Scenario both in environmental effects and effects on the general economy. Areas that suffer from these effects, of course, exist and for this analysis, they occur primarily in items of higher resource usage.

In energy requirements, the Reference Abatement Scenario generates a demand requiring a 3.3 percent increase for 1980 and 3.6 percent by 1985. The annual rates of growth over the decade were similar, as were demands for specific energy sources. The reasons for the increased demand were both the additional energy requirements resulting from the generally higher economic output coupled with the incremental energy consumption by pollution control devices. The period of greatest relative increase in energy use is reached at the

point of full implementation of air pollution controls for existing plants and water BPT controls (1977-80). Iron, aluminum and copper usage also reflects the stimulated manufacturing output levels, as does paper recycling. Aluminum and ferrous materials, although more of these show the same case pattern as energy. The other resource categories decrease with time after the implementation of the capital building stage, energy continues to grow in use.

Finally, the consideration of the demand for transportation reveals that vehicle-kilometers decline slightly in the Reference Abatement Scenario after 1980. The increase in freight metric-ton kilometers over the decade in the Reference Abatement Scenario is a result of higher manufacturing output.

Prior to presenting a detailed analysis of interindustry effects for the Reference Case scenarios, other scenario pairs are analyzed to provide an appreciation of the effects of abatement policies given changes in other parts of the national economy that are beyond the control of EPA policy makers.

\$bCOMPARATIVE ANALYSIS OF

LOW-PRODUCTIVITY FORECASTS\$R

The Low Productivity Case scenarios provide a range of economic conditions that allow for a greater appreciation of the relative impacts of abatement regulations. The two scenarios are labelled the Low Productivity Scenario and the Low Productivity Abatement Scenario. The principal difference between the Reference Case Scenarios and the two Low Productivity scenarios is that the basic data for productivity in each industry and the expenditures which comprise the GNP elements were used directly from the INFORUM-supplied data base in the Low Productivity scenario and the Low Productivity Abatement Scenario. This set of data results in a less optimistic economic forecast relative to the Reference Scenario, as shown in Figure 3. To translate from the Low Productivity Scenario to the Low Productivity Abatement Scenario, the same steps were taken as in going from the Reference Scenario to the Reference Abatement Scenario (see three steps given above).

A summary of the Low Productivity Scenario results is presented in Table 9. Table 10 provides a comparison of the two scenarios that include no incremental pollution control costs (the Reference and the Low Productivity Scenarios). In terms of GNP, the Low Productivity Scenario results from

1975 are greater than the projections used in the Reference Scenario. By 1977, the two scenarios have essentially equal GNP, and then the lower productivity assumptions rapidly reduce the relative level of GNP so that by 1985 it is nearly 12 percent lower than the Reference Scenario (\$2.088 versus \$2.365 trillion, 1975 constant dollars). The unemployment rates for the two scenarios are similar. Total output and personal consumption expenditures are consistent with the GNP forecasts.

| 987

| 988

Figure 3.

Scenario Projections of GNP

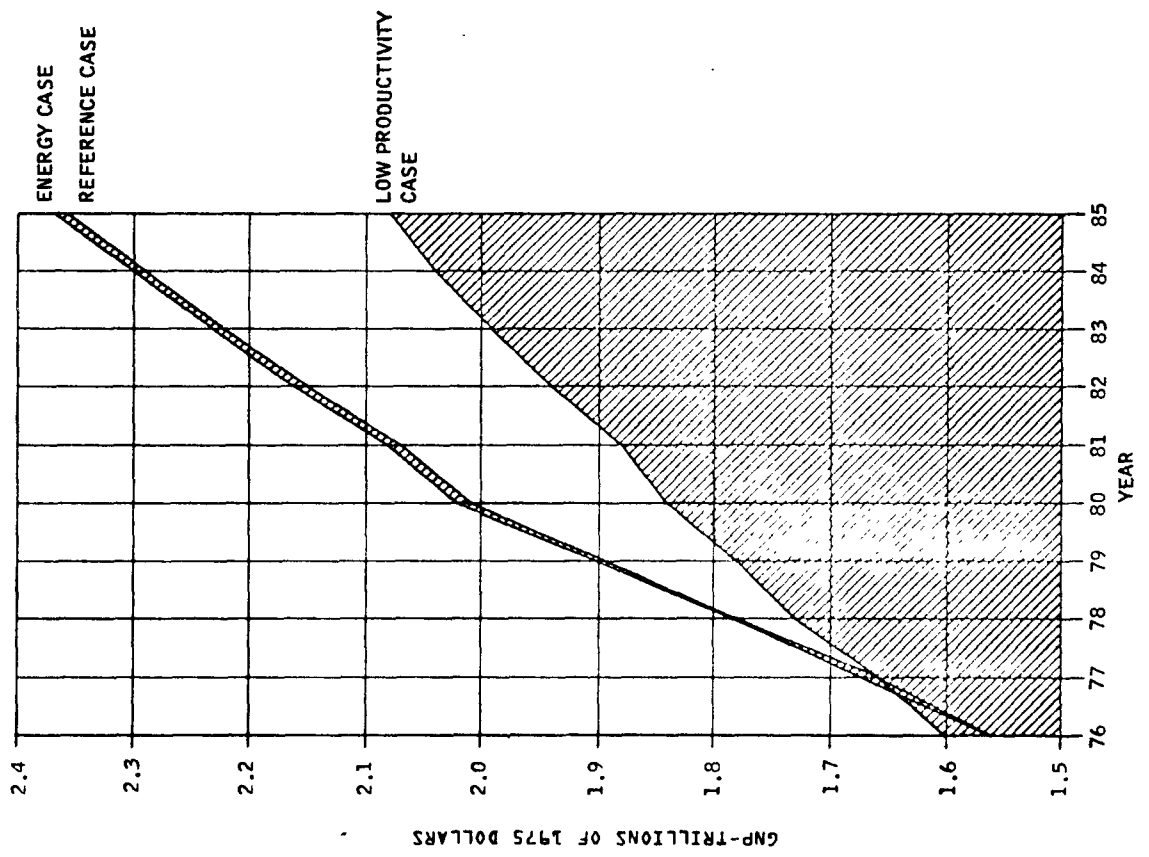


Table 9.
General Projections of the Low Productivity Scenario (\$3),
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	221.90	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	7.90	7.20	6.10	5.50	5.20	5.30	4.90	4.70	4.50	4.40
Disposable Income										
Per Capita (1,000 1975 \$)	5.92	6.05	6.46	6.57	6.76	6.85	7.07	7.12	7.26	7.33
Gross National Product (Trillion 1975 \$)	1.60	1.66	1.73	1.78	1.84	1.88	1.94	1.99	2.04	2.08
Personal Consumption Expenditures	0.99	1.03	1.10	1.13	1.17	1.21	1.25	1.28	1.32	1.36
Investment	0.27	0.28	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.33
Government Expenditures	0.31	0.32	0.33	0.34	0.35	0.35	0.36	0.37	0.38	0.38
Federal	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.13
Other	0.20	0.21	0.22	0.23	0.23	0.23	0.24	0.24	0.25	0.25
Total Output (Trillion 1975 \$)	2.68	2.80	2.91	3.01	3.12	3.20	3.32	3.40	3.50	3.59
Manufacturing	1.12	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.44
Total Energy Use (Quadrillion BTU's)	81.28	83.64	85.62	87.46	89.27	91.45	94.23	96.66	99.36	102.04
Natural Gas	19.43	18.99	19.15	19.20	19.28	19.33	19.52	19.58	19.70	19.77
Petroleum	31.91	32.48	33.07	33.59	34.03	34.74	35.59	36.31	37.05	37.77
Coal	4.71	4.86	4.86	4.93	5.02	5.10	5.25	5.34	5.46	5.56
Electricity	25.23	27.29	28.54	29.73	30.93	32.28	33.87	35.43	37.15	38.95
U.S. Demand (Million Metric Tons)										
Copper	2.45	2.62	2.67	2.70	2.74	2.76	2.86	2.93	2.99	3.04
Iron	146.60	150.40	144.30	147.50	150.10	150.00	151.90	152.70	154.10	155.00
Aluminum	4.85	5.11	5.17	5.37	5.55	5.68	5.88	6.05	6.22	6.39
Recycled Materials (Million Metric Tons)										
Paper	69.89	72.70	74.56	76.63	79.02	81.03	83.78	85.86	88.03	89.60
Aluminum	6.40	6.70	7.00	7.30	7.56	7.76	8.05	8.24	8.47	8.60
Ferrous Metals	1.39	1.50	1.51	1.62	1.77	1.92	1.95	2.03	2.16	2.20
	41.90	43.50	44.10	45.10	46.29	47.36	48.84	50.07	51.04	51.70

Table 9. (Continued)
General Projections of the Low Productivity Scenario (S3),
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Vehicle Kilometers (Trillions)										
Auto	1.68	1.71	1.81	1.81	1.84	1.87	1.93	1.95	2.00	2.03
Total Freight Metric Ton-Kilometers (Billions)	1.67	1.70	1.79	1.79	1.82	1.85	1.86	1.94	1.98	2.01
Truck	3.64	3.76	3.85	3.94	4.03	4.14	4.28	4.33	4.52	4.65
Rail	0.75	0.78	0.81	0.85	0.88	0.91	0.96	1.00	1.04	1.08
	1.17	1.20	1.22	1.25	1.27	1.29	1.33	1.36	1.39	1.42
Net Air Residuals (Million Metric Tons)										
Particulates	39.22	40.55	41.02	41.65	42.21	42.72	43.73	44.29	45.08	45.74
Sulfur Oxides	37.90	40.40	40.80	41.30	41.70	41.80	42.50	42.90	43.60	44.30
Nitrogen Oxides	19.10	20.00	20.60	21.00	21.40	21.70	22.40	22.80	23.40	24.00
Hydrocarbons	12.50	12.50	12.70	12.70	12.70	12.90	13.20	13.40	13.70	13.90
Carbon Monoxide	74.70	76.80	80.30	81.20	83.00	84.70	87.80	89.20	91.50	93.10
Net Water Residuals (Million Metric Tons)										
Biochemical Oxygen Demand	5.00	5.20	5.30	5.40	5.60	5.60	5.80	5.90	6.00	6.10
Suspended Solids	12.00	12.30	12.50	12.70	13.00	13.10	13.40	13.60	13.80	14.00
Dissolved Solids	12.50	12.70	13.00	13.10	13.20	13.20	13.30	13.30	13.40	13.40
Nutrients	1.50	1.60	1.60	1.60	1.60	1.60	1.70	1.70	1.70	1.70
Air Costs										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Cost	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0

Table 9. (Continued)
General Projections of the Low Productivity Scenario (S3).
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Industrial Cost										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0
Municipal Costs										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment	0	0	0	0	0	0	0	0	0	0

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$s\$Rc

Table 10.
Comparison of the Macro-Statistics of the
Low Productivity Scenario (S3) and the Reference Scenario (S1)
[(S3-S1)/S1 in %] in Selected Years

Statistic	1975	1977	1980	1983	1985
Gross National Product	3.98	0.28	-8.39	-10.39	-11.68
Disposable Income Per Capita	7.28	0.97	-10.39	-14.31	-16.43
Federal Expenditures	0.0	0.0	0.0	0.0	0.0
Personal Consumption Expenditures	4.61	0.95	-7.77	-11.18	-12.98
Total Output	3.85	0.15	-8.53	-10.30	-11.51
Manufacturing	2.99	-0.39	-9.47	-10.35	-12.27
Investment	2.65	-1.50	-13.47	-12.78	-12.78
Energy Use	2.10	0.19	-4.65	-5.70	-6.39
Demand: Iron	3.96	0.12	-9.81	-9.10	-9.58
Aluminum	2.69	-0.38	-10.05	-10.10	-10.88
Recycling: Paper	4.55	0.60	-8.36	-10.73	-13.04
Aluminum	1.94	-0.66	-6.34	-6.45	-7.17
Ferrous Metals	1.50	-0.46	-4.97	-7.17	-5.21
Vehicle Kilometers Travelled	7.27	0.60	-10.24	-14.47	-16.12
Freight Metric Ton-Kilometers	3.09	0.00	-7.36	-8.54	-9.36
Net Air Residuals:					
Particulates	2.98	0.05	-7.16	-8.33	-9.40
Sulfur Oxides	2.63	0.09	-6.64	-8.39	-9.66
Nitrogen Oxides	4.01	0.39	-7.56	-10.01	-11.50

Table 10. (Continued)
 Comparison of the Macro-Statistics of the
 Low Productivity Scenario (S3) and the Reference Scenario (S1)
 [(S3-S1)/S1 in %] in Selected Years

Hydrocarbons	5.42	0.50	-8.60	-11.21	-12.73
Carbon Monoxide	6.35	0.65	-10.03	-13.31	-15.13
Net Water Residuals:					
Biochemical Oxygen Demand	2.40	0.01	-4.87	-5.96	-6.77
Suspended Solids	2.77	-0.17	-6.09	-7.40	-8.11
Dissolved Solids	4.07	0.25	-8.04	-10.09	-11.51
Nutrients	0.24	-0.02	-0.51	-0.60	-0.69

The impact of the lower productivity assumptions is readily seen: at quite consistent unemployment rates, considerable reductions in funds available for personal purchases are required in order to maintain full-supply GNP. The historical projections of productivity are greater than the actual 1975 factors and are nearly balanced in the 1977 forecasts. The greatest divergence occurs over the period 1977-80, but significant change continues through 1985. The percentage differences in the personal consumption expenditures for 1980, 1983 and 1985 are -7.8 percent, -11.2 percent and -13.0 percent, respectively. Between the two scenarios, the drop in equipment and construction investment was greater than the change in GNP, while total output paralleled the GNP change. The impact of economic differences on transportation was significant, with the passenger-miles travelled reduced. The annual freight-metric-ton-kilometers-moved reduction for the period of 1977-85 was on the order of 2 to 3 percent.

The effects on material usage, as measured by U.S. demands for the three commodities of iron, aluminum and copper, follow the expected trends for the period 1980-85. Iron demand is off by about 10 percent, aluminum by 11 percent and copper by 10 percent over the 6-year period. Demands for recycled materials, as typified by aluminum and paper products, also are reduced. The decrease in secondary

aluminum is off 7 percent, only two-thirds of the drop in demand for primary aluminum ore. For paper, the drop in demand was from 8.5 percent to 12 percent over the period 1980-85.

The energy budgets also show significant reductions. Total usage in quadrillion Btu's drop from 93.6 to 89.3 in 1980 (4.6 percent drop) and from 109 to 102 (6.4 percent drop) for 1985 between the Reference Scenario and the Low Productivity Scenario. The decreases in fuel usage are postulated to be in the usage of natural gas, petroleum, and coal, with usage of nuclear and hydroelectric power constant between the two scenarios. For the Low Productivity scenario, the contributions of coal and nuclear fuels to electric power generation by electric utilities are about equal, with each providing 32 percent of source energy.

Thus, although energy demand decreases from the Reference Scenario, the change is only about half that of the relative decrease in the growth of the economy and other material resources. The impact on the air and water category environmental residuals follow the changes in economic indicators. Table 11 provides the relative levels of residuals.

Table 11.
Relative Levels of Environmental Residuals
Low Productivity Scenario/Reference Scenario (S3/S1)

\$t	1977	1980	1983	1985
Air Residuals				
Stationary Sources				
Particulates	100%	93%	92%	91%
Sulfur Oxides	100%	93%	92%	90%
Nitrogen Oxides	100%	94%	92%	90%
Hydrocarbons	100%	93%	92%	91%
Carbon Monoxide	99%	91%	90%	90%
Mobile Sources				
Particulates	101%	91%	88%	86%
Sulfur Oxides	100%	92%	90%	88%
Nitrogen Oxides	101%	91%	88%	87%
Hydrocarbons	101%	90%	86%	84%
Carbon Monoxide	101%	90%	86%	84%
Water Residuals				
Biochemical				
Oxygen Demand	100%	95%	94%	93%
Suspended Solids	100%	93%	93%	92%
Dissolved Solids	100%	92%	90%	88%
Nutrients	100%	99%	99%	99%\$R

\$bCOMPARATIVE ANALYSIS FOR THESE
\$bLOW-PRODUCTIVITY SCENARIOS\$b

The fourth scenario used in the general impact analysis, the Low Productivity Abatement Scenario, varies from its predecessor, the Low Productivity Scenario, in the same fashion as the Abatement Scenario varies from the Reference Scenario. Thus, a comparison of the statistics of the Low Productivity Abatement Scenario with those of the Low Productivity Scenario provides an impact analysis of Federal pollution control laws and regulations given low growth economic conditions.

Table 12 provides the general statistics for this scenario in a comparable form to the values given for the Reference Abatement Scenario in Table 4. The general comparative economic trends continue for this analysis. The stimulus to economic output due to compliance with Federal pollution control laws and regulations are in evidence throughout the decade as shown in Table 13. Through 1980, there is sufficiently high unemployment in the Low Productivity Scenario so that the additional labor force required for abatement is assumed to be available.

\$dTable 12
General Projections of the Low Productivity Abatement Scenario (S4),
1976-1985

\$t Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	221.90	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	6.40	5.30	4.50	4.00	4.20	4.30	4.20	4.20	4.10	4.10
Disposable Income Per Capita (1,000 1975 \$)	5.91	6.13	6.49	6.66	6.76	6.92	7.05	7.14	7.23	7.31
Gross National Product (Trillion 1975 \$)	1.65	1.72	1.77	1.82	1.86	1.91	1.96	2.00	2.04	2.09
Personal Consumption Expenditures	1.01	1.05	1.11	1.15	1.18	1.22	1.26	1.29	1.32	1.36
Investment	0.29	0.31	0.29	0.30	0.31	0.31	0.32	0.32	0.33	0.33
Government Expenditures	0.33	0.34	0.35	0.35	0.36	0.36	0.37	0.38	0.39	0.39
Federal	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14
Other	0.21	0.22	0.23	0.23	0.24	0.24	0.24	0.25	0.25	0.25
Total Output (Trillion 1975 \$)	2.77	2.90	3.00	3.09	3.17	3.26	3.35	3.44	3.53	3.61
Manufacturing	1.17	1.23	1.25	1.28	1.31	1.34	1.37	1.40	1.43	1.46
Total Energy Use (Quadrillion Btu's)	84.90	87.59	89.36	91.17	92.59	94.92	97.48	100.02	102.83	105.67
Natural Gas	20.16	19.79	19.86	19.92	19.88	19.96	20.08	20.16	20.33	20.41
Petroleum	33.56	34.11	34.40	34.94	35.20	35.88	36.62	37.31	38.01	38.68
Coal	4.99	5.18	5.14	5.16	5.16	5.25	5.34	5.44	5.53	5.63
Electricity	26.19	28.51	29.86	31.15	32.35	33.63	35.44	37.12	39.02	40.94
U.S. Demand (Million Metric Tons)										
Copper	2.59	2.78	2.79	2.79	2.80	2.82	2.90	2.97	3.00	3.05
Iron	154.16	158.90	152.38	152.10	151.27	151.22	151.12	151.18	151.20	152.70
Aluminum	5.06	5.36	5.38	5.52	5.64	5.77	5.93	6.09	6.23	6.39
Recycled Materials (Million Metric Tons)										
Paper	71.45	74.41	75.90	79.80	79.59	81.81	84.13	86.37	88.38	90.09
Aluminum	6.51	6.82	7.14	7.40	7.59	7.82	8.06	8.25	8.47	8.67
Ferrous Metals	1.43	1.56	1.56	1.65	1.79	1.94	1.97	2.05	2.17	2.21
\$R	42.97	44.61	45.05	45.86	46.70	47.79	49.14	50.44	51.41	52.21

Table 12. (Continued)
General Projections of the Low Productivity Abatement Scenario (S4).
1976-1985

\$t Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Vehicle Kilometers (Trillions)										
Auto	1.70	1.74	1.81	1.82	1.83	1.89	1.92	1.95	1.98	2.01
Freight Metric Ton-	1.69	1.72	1.80	1.80	1.82	1.87	1.90	1.94	1.97	2.00
Kilometers (Billions)										
Truck	3.79	3.94	4.00	4.08	4.14	4.25	4.37	4.49	4.61	4.73
Rail	0.78	0.82	0.85	0.88	0.90	0.94	0.98	1.02	1.06	1.10
	1.22	1.26	1.27	1.29	1.30	1.33	1.36	1.39	1.42	1.45
Net Air Residuals (Million Metric Tons)										
Particulates	16.42	9.55	9.33	9.33	9.37	9.51	8.73	7.92	7.05	6.18
Sulfur Oxides	20.04	14.84	15.14	15.41	15.60	15.84	15.76	16.23	16.49	16.77
Nitrogen Oxides	19.24	20.12	20.50	20.64	20.66	20.86	21.29	21.58	21.83	22.14
Hydrocarbons	10.51	9.67	9.30	8.77	8.26	7.89	7.29	6.65	6.13	5.59
Carbon Monoxide	60.93	56.30	52.48	47.66	42.88	38.94	34.44	31.05	27.61	25.61
Net Water Residuals (Million Metric Tons)										
Biochemical Oxygen Demand	3.01	2.12	1.63	1.62	1.62	1.49	1.36	1.21	1.06	1.04
Suspended Solids	7.29	4.72	2.66	2.57	2.23	2.24	1.89	1.52	1.14	1.10
Dissolved Solids	12.02	11.73	11.39	11.46	11.44	10.47	9.60	8.78	8.07	8.24
Nutrients	1.33	1.24	1.18	1.12	1.07	1.01	0.95	0.89	0.83	0.77
Air Control Costs (Billion 1975 \$)										
Investment	11.12	12.67	16.56	13.42	12.78	12.77	12.90	13.01	13.14	13.07
Annualized Costs										
Capitals	9.66	11.73	15.17	17.88	20.22	22.29	24.09	25.64	26.93	27.93
O&M	9.67	9.57	9.34	9.51	9.50	9.34	9.21	9.07	8.93	8.77
Capital in Place	44.71	54.05	65.94	73.86	80.32	85.97	91.01	95.38	99.10	101.98
Direct Employment (Thousands)	15	17	19	20	20	20	20	19	19	19

\$R

Table 12. (Continued)
General Projections of the Low Productivity Abatement Scenario (S4).
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Water Industrial Costs (Billion 1975 \$)										
Investment	5.89	8.01	4.93	4.16	5.97	5.91	5.81	5.44	1.61	1.34
Annualized Costs										
Capital	2.27	3.28	3.88	4.37	5.10	5.83	6.58	7.29	7.48	7.64
O&M	3.79	5.12	5.84	6.08	6.29	6.50	6.76	7.07	10.25	10.61
Capital in Place	17.62	25.63	30.50	34.61	40.51	46.36	52.91	57.49	48.96	60.15
Direct Employment (Thousands)	119	160	184	193	201	209	219	230	347	361
Water Municipal Costs (Billion 1975 \$)										
Investment	6.55	8.11	8.13	5.59	2.94	1.77	0.80	0.70	0.70	0.53
Annualized Costs										
Capital	2.27	3.17	4.06	4.68	5.00	5.20	5.28	5.36	5.44	5.50
O&M	0.68	0.93	1.36	1.61	1.76	1.84	1.89	1.93	1.97	2.00
Capital in Place	20.63	28.74	36.88	42.47	45.41	47.17	47.97	48.67	49.37	49.90
Direct Employment (Thousands)	20	27	40	48	52	54	56	57	58	59

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$R\$\$

Table 13.
Comparison of the Macro-Statistics of the Low
Productivity Abatement Scenario (S4) and the Low Productivity Scenario (S3)
[(S4-S3)/S3 in %]

Statistic	1975	1977	1980	1983	1985
Gross National Product	2.01	3.06	1.11	0.73	0.17
Disposable Income Per Capita	0.07	1.29	0.00	0.22	-0.30
Federal Expenditures	0.24	1.05	2.25	2.19	2.16
Personal Consumption Expenditures	0.61	1.34	0.35	0.29	-0.10
Total Output	2.41	3.48	1.41	0.96	0.46
Manufacturing	3.05	4.21	1.71	1.09	0.48
Investment	7.68	8.49	3.44	1.76	0.10
Energy Use	4.55	4.72	3.72	3.48	3.56
Demand: Iron	4.16	5.65	0.78	-0.99	-1.48
Aluminum	3.52	4.69	1.62	0.66	0.00
Recycling: Paper	0.64	1.73	0.40	0.12	0.54
Aluminum	2.35	4.00	1.12	0.99	0.81
Ferrous Metals	1.77	2.55	0.89	0.74	0.98
Vehicle Kilometers Travelled	0.07	1.75	-0.54	0.00	-0.98
Freight Ton-Kilometers	3.61	4.62	2.47	1.96	1.66
Net Air Residuals:					
Particulates	-42.69	-80.73	-81.43	-84.41	-87.49
Sulfur Oxides	-32.68	-63.25	-62.60	-62.22	-62.22
Nitrogen Oxides	0.12	0.24	-3.58	-5.56	-7.86
Hydrocarbons	-13.43	-22.43	-35.48	-50.47	-59.82
Carbon Monoxide	-18.14	-26.77	-48.34	-65.23	-72.95
Net Water Residuals:					
Biochemical Oxygen Demand	-22.26	-59.37	-71.19	-79.55	-83.14
Suspended Solids	-17.73	-60.10	-78.57	-87.13	-90.52
Dissolved Solids	-0.91	-8.05	-13.76	-34.35	-38.63
Nutrients	-9.94	-22.55	-32.37	-47.91	
\$R\$\$					

The relative impact of pollution control expenditures costs is shown in Table 14, which presents these costs as a percentage of the Low Productivity Scenario GNP. These proportions can be compared with similar data for the Reference Case given in Table 6.

Table 14.
Pollution Control Costs as a Percentage
of Low Productivity Scenario GNP

\$t	1977	1980	1983	1985	1976-85
Air Stationary Source Costs					
Capital Costs	0.37	0.05	0.04	0.03	0.13
O&M Costs	0.21	0.27	0.25	0.24	0.26
Water Industrial Costs					
Capital Costs	0.48	0.32	0.25	0.06	0.26
O&M Costs	0.31	0.34	0.36	0.51	0.37
Water Municipal Costs					
Capital Costs	0.49	0.16	0.04	0.03	0.19
O&M Costs	0.06	0.10	0.10	0.10	0.09

Comparing the statistics of Tables 6 and 14 demonstrates that the level of impact at the macroeconomic level is similar for the two economic projections. Hence, over the economic ranges of growth given in these situations, it is likely that the level of impact is reasonably constant. The indirect impacts also are similar in terms of higher

employment levels in the Abatement Scenario as compared to the Non-Abatement Scenario.

Tables 15 and 16 provide aggregate pollutant treatment projections for the Low Productivity Abatement Scenario that are comparable to the Reference Abatement Scenario values of Tables 7 and 8. As can be noted, the efficiency levels are comparable, with consistent trends for all residuals. In all cases the levels are nearly the same, suggesting that the level of economic output has no major effect on aggregate treatment levels.

In a similar vein, the changes in material and energy usage in the non-Federal control and the Federal control scenarios are similar for the two economic levels. Thus, in terms of macroeconomic impacts, the introduction of Federally-imposed pollution controls produces consistent effects for the high growth economy (CEA/BLS) Reference Abatement Scenario and the low economic growth Low Productivity Abatement Scenario.

\$dTable 15.
Relative Stationary Sources Treatment Efficiencies of
Selected Pollutants for the Low Productivity Abatement Scenario
\$t

	1975		1980		1985	
	Low Productivity	Low Productivity Abate	Low Productivity	Low Productivity Abate	Low Productivity	Low Productivity Abate
Air Residuals						
Particulates	60.7	-77.4	61.2	92.5	61.5	95.3
Sulfur Oxides	25.5	52.5	26.6	73.9	25.7	73.5
Nitrogen Oxides	0.2	2.5	0.2	5.6	0.3	5.7
Hydrocarbons	39.3	50.9	40.4	59.5	42.3	71.1
Carbon Monoxide	42.3	56.2	41.9	64.9	42.2	66.6
Water Residuals						
Biochemical Oxygen Demand	66.7	74.3	66.4	90.4	66.4	94.3
Suspended Solids	80.2	84.4	80.7	96.1	81.3	98.3
Dissolved Solids	30.9	33.9	32.3	44.1	34.6	61.9
Nutrients	28.0	35.7	30.4	56.1	32.4	70.9\$R

\$dTable 16.
Transportation Emission Levels for the Low Productivity Abatement
Scenario (Metric Tons per Million Vehicle Kilometers Travelled)

	1975		1980		1985	
	Low Productivity	Low Productivity Abate	Low Productivity	Low Productivity Abate	Low Productivity	Low Productivity Abate
Air Residuals						
Particulates	0.48	0.43	0.51	0.43	0.55	0.44
Sulfur Oxides	0.36	0.36	0.39	0.39	0.41	0.42
Nitrogen Oxides	5.26	5.12	5.57	5.15	5.85	4.63
Hydrocarbons	4.54	3.93	3.85	2.31	3.74	1.18
Carbon Monoxide	36.96	30.23	37.43	18.58	37.95	7.77\$R

ANALYSIS OF RELATIVE MACRO

LEVEL IMPACTS FROM ENERGY

CONSERVATION SCENARIOS

To further demonstrate the possible variations in pollution control costs because of different situations and policies in the future, a pair of scenarios was constructed which approximated energy usage forecasts in the Federal Energy Administration's "Business-as-Usual-with-Conservation" scenario, where the price of imported oil was \$11 per barrel. In the analysis, it was assumed that this reduction in energy use could be achieved by the following actions:

1. Reduced household consumption of space-heating and cooling energy due to improved insulation and higher summer and lower winter thermostat settings.
2. Reduced per capita gasoline use through increased carpooling, increased use of mass transit, and improved auto fuel consumption efficiency.
3. A reduction in the interindustry fossil fuel use coefficients for energy-intensive products as inputs to production by substitution of less energy-intensive inputs. These measures include shifts

to returnable beverage containers, reductions in the use of artificial fertilizers, reduced use of packaging materials, and some recycling of energy-intensive materials.

4. Miscellaneous changes to reflect improved energy housekeeping activities.

The first of the Energy Conservation scenarios, without the Federally-imposed pollution controls, is the Energy Scenario. The second, introducing the effects of pollution control by the same four steps given earlier, is the Energy Abatement Scenario.

A set of output statistics for the Energy Scenario is provided in Table 17. Some of the primary economic factors are highlighted in Table 18. These differences occur under the conditions that the primary factors that alter GNP, the final demand accounts of personal consumption expenditures and Federal expenditures, were held at the same levels for the Reference and the Energy Scenarios, and for the Reference and Energy Abate Scenarios. Thus, the impacts are solely caused by purchase changes due to energy conservation measures introduced in the Energy Scenario.

Table 17.
General Projections of the Energy Scenario (\$B).
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	221.90	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	7.90	6.90	5.80	5.20	4.70	5.10	4.60	4.40	4.30	4.20
Disposable Income Per Capita (1,000 1975 \$)	5.62	5.99	6.61	7.04	7.54	7.74	8.07	8.31	8.53	8.78
Gross National Product (Trillion 1975 \$)	1.56	1.67	1.78	1.90	2.02	2.08	2.16	2.23	2.30	2.37
Personal Consumption Expenditures	0.97	1.03	1.12	1.19	1.28	1.33	1.39	1.45	1.51	1.56
Investment	0.26	0.29	0.29	0.32	0.35	0.35	0.36	0.36	0.37	0.38
Government Expenditures	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41
Federal	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14
Other	0.20	0.21	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27
Total Output (Trillion 1975 \$)	2.61	2.81	3.00	3.21	3.43	3.54	3.67	3.80	3.93	4.05
Manufacturing	1.10	1.18	1.25	1.34	1.43	1.46	1.50	1.54	1.58	1.62
Total Energy Use (Quadrillion Btu's)	76.55	79.36	81.66	84.26	86.80	88.47	90.31	92.14	94.00	95.70
Natural Gas	18.81	18.70	19.07	19.43	19.79	19.88	20.06	20.21	20.39	20.53
Petroleum	28.70	29.24	29.67	30.18	30.61	30.81	31.02	31.24	31.44	31.57
Coal	4.59	4.89	4.99	5.24	5.48	5.57	5.66	5.76	5.88	6.00
Electricity	24.45	26.53	27.93	29.40	30.91	32.21	33.58	34.93	36.30	37.61
U.S. Demand (Million Metric Tons)										
Copper	2.34	2.60	2.74	2.89	3.04	3.07	3.13	3.19	3.25	3.31
Iron	156.70	151.48	150.47	160.07	168.57	168.05	167.11	167.43	168.22	169.24
Aluminum	4.71	5.14	5.38	5.78	6.18	6.31	6.42	6.56	6.71	6.86
Recycled Materials (Million Metric Tons)										
Paper	68.78	73.01	76.22	80.27	84.61	86.67	89.14	91.55	93.73	96.42
Aluminum	6.23	6.67	7.22	7.73	8.28	8.57	8.93	9.26	9.60	9.92
Ferrous Metals	1.37	1.52	1.56	1.69	1.90	2.04	2.05	2.12	2.24	2.26
\$R	41.49	43.74	44.96	46.84	48.82	49.87	51.04	52.20	53.04	53.71

Table 17. (Continued)
General Projections of the Energy Scenario (\$5),
1976-1985

Statistics	\$t	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Vehicle Kilometers (Trillions)		1.49	1.54	1.66	1.72	1.82	1.86	1.93	1.99	2.03	2.08
Auto		1.47	1.53	1.64	1.71	1.80	1.83	1.90	1.96	2.00	2.05
Freight Metric Ton -											
Kilometers		3.52	3.77	3.94	4.16	4.39	4.50	4.64	4.79	4.93	5.08
(Billions)											
Truck		0.73	0.79	0.84	0.90	0.96	1.00	1.04	1.09	1.14	1.19
Rail		1.14	1.21	1.26	1.32	1.38	1.41	1.45	1.48	1.52	1.56
Net Air Residuals											
(Million											
Metric Tons)		37.42	39.75	41.32	43.46	45.51	46.12	46.73	47.19	47.88	48.24
Particulates		36.20	39.20	40.20	41.50	42.90	43.00	43.30	43.50	43.50	44.20
Sulfur Oxides		18.50	19.80	20.80	21.80	22.80	23.30	24.00	24.60	25.30	25.90
Nitrogen Oxides		12.00	12.10	12.70	13.10	13.50	13.70	14.10	14.40	14.70	15.00
Hydrocarbons		71.96	76.10	81.90	86.50	91.80	94.60	98.80	102.10	105.20	108.60
Carbon Monoxide											
Net Water Residuals											
(Million											
Metric Tons)		5.00	5.20	5.50	5.70	5.90	6.00	6.20	6.30	6.40	6.60
Biochemical Oxygen		11.78	12.30	12.80	13.40	14.00	14.20	14.40	14.70	14.90	15.10
Demand		12.10	12.60	13.20	13.70	14.30	14.30	14.50	14.60	14.60	14.70
Suspended Solids		1.58	1.60	1.60	1.60	1.70	1.70	1.70	1.70	1.70	1.80
Dissolved Solids											
Nutrients											
\$R											

Table 17. (Continued)
General Projections of the Energy Scenario (\$'s).
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Air Control Costs (Billion 1975\$)										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment (Thousands)	0	0	0	0	0	0	0	0	0	0
Water Industrial Costs (Billion 1975 \$)										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment (Thousands)	0	0	0	0	0	0	0	0	0	0
Water Municipal Costs (Billion 1975 \$)										
Investment	0	0	0	0	0	0	0	0	0	0
Annualized Costs	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0
Capital in Place	0	0	0	0	0	0	0	0	0	0
Direct Employment (Thousands)	0	0	0	0	0	0	0	0	0	0

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$sR

Table 18.
Summary of Major Economic
Factors from the Energy Scenario

\$t	1975	1977	1980	1983	1985
GNP (Billion 1975 \$)					
Energy Reference	1.470	1.669	2.019	2.227	2.370
Difference	0	+4	+7	+6	+5
Employment (Millions)					
Energy Reference	86.1	90.4	97.1	101.1	103.2
Difference	0	+0.1	+0.3	+0.1	+0.1
Investment (Billion 1975 \$)					
Energy Reference	221	285	344	362	377
Difference	0	-1	0	-2	-4
Net Exports (Billion 1975 \$)					
Energy Reference	10.5	11.3	8.6	6.2	1.2
Difference	-0.1	3.6	7.1	-2.6	-8.9
\$R				8.8	10.1

It can be seen that the major factor in raising GNP is the increased net exports and that, for some years, the level of investment expenditures declines slightly. Both imports and exports fall, with imports decreasing at a faster rate.

Turning to total output, for most years the output of the Energy Scenario is about 5 percent higher than the Reference Scenario; however, the pattern is erratic. In the major sector of manufacturing output, little difference is noted in the levels of production between the two scenarios.

To indicate changes in energy and material consumption between the two scenarios, Table 19 provides annual usage for petroleum, coal, electricity, iron ore, aluminum and copper. (Note that Petroleum and Coal figures in Table 19 include use for generating electricity. Table 17 figures do not include this factor to avoid double-counting in energy use.) The trends are consistent with the variations in assumptions. Petroleum demand and electricity demand decline in 1985 by approximately 21 percent and 8.5 percent, respectively. Slight decreases in use of iron, aluminum and copper are noted with no decline greater than 4.5 percent, which is consistent with the variation in manufacturing output.

Table 19.
Comparison of Energy & Material Usage
Between the Reference and Energy Scenarios

St	1975	1977	1980	1983	1985
Petroleum (Btu's Quadrillions)					
Energy	32.1	33.8	36.1	37.2	37.9
Reference	34.3	37.2	41.4	45.0	47.6
Difference	-2.2	-3.4	-5.3	-7.8	-9.7
Coal (Btu's Quadrillions)					
Energy	13.8	16.6	17.7	17.6	17.6
Reference	13.9	17.0	18.4	19.0	19.8
Difference	-0.1	-0.4	-0.7	-1.4	-2.2
Electricity (Btu's Quadrillions)					
Energy	22.5	26.5	30.9	34.9	37.6
Reference	22.8	27.3	32.1	37.1	41.1
Difference	-0.3	-0.8	-1.2	-2.2	-3.5
Iron Ore (Million Metric Tons)					
Energy	129	151	169	168	169
Reference	129	150	166	168	171
Difference	0	1	3	0	-2
Aluminum (Million Metric Tons)					
Energy	4.2	5.1	6.2	6.6	6.9
Reference	4.2	5.1	6.2	6.7	7.2
Difference	0	0	0	-0.1	-0.3
Copper (Million Metric Tons)					
Energy	2.1	2.6	3.0	3.2	3.3
Reference	2.1	2.6	3.0	3.2	3.4
Difference	0	0	0	0	-0.15R

A final comparison of the effects of energy conservation.

Table 30 provides the level of environmental residuals

produced in the Energy Scenario relative to the Reference

Scenario, as shown in Table 20.

Table 20.
Environmental Residuals from Energy Scenario (\$5)
as a Percentage of Reference Scenario Residuals (\$1)
(\$5/\$1 in %)

\$t	1975	1977	1980	1983	1985
Air Residuals					
Stationary Sources					
Particulates	99	98	98	96	94
Sulfur Oxides	98	97	96	93	90
Nitrogen	98	97	96	93	89
Hydrocarbons	95	95	92	89	87
Carbon					
Monoxide	98	99	98	97	96
Mobile Sources					
Particulates	94	95	95	94	94
Sulfur Oxides	98	100	102	103	104
Nitrogen Oxides	95	96	96	95	94
Hydrocarbons	92	91	89	87	86
Carbon					
Monoxide	92	90	88	86	85
Water Residuals					
Biochemical Oxygen Demand	100	100	100	100	100
Suspended Solids	100	100	100	100	99
Dissolved Solids	100	99	99	98	97
Nutrients	100	100	100	100	100\$R

In general, for water residuals, little impact is noted since the energy conservation assumptions do not cause major variations in the industries that produce the majority of water pollutants. The reduction in mobile source emissions is consistent with the major reduction in auto mileage, with concomitant small increases in mass transit and small decreases in freight demands.

The major impact is in stationary source air emissions except for particulates. Reduction of sulfur oxides is not as great as for nitrogen oxides, hydrocarbons, and carbon monoxide due to the increased use of coal. The lesser reduction for particulates is due to a mixed reaction in the six major producing sectors. The changes in particulate generation in 1985 due to the energy conservation changes are:

\$t	Concrete, Asbestos	-0.4%
	Electricity	-12.9%
	Petroleum	-14.0%
	Iron & Steel	-1.6%
	Grain Handling	+2.6%
	Pulp & Paper	-2.0%\$R

In summary, the Energy Conservation scenario assumptions produced a major effect on energy consumption and air pollution emissions.

The effects of the pollution control regulations are provided by comparing the Energy Abatement Scenario with its predecessor, the Energy Scenario. The basic output statistics for the Energy Abatement Scenario are given in Table 21.

Table 22 compares the results of Energy Abatement Scenario with those of the Energy Scenario. As in the other scenario pairs, the scenario that included the pollution control costs and purchases provided higher employment, GNP and total output for all years. The differences were greatest for the years 1975 and 1977 when the available labor force was sufficient to provide for the increased resource needs due to abatement controls. By 1985, Energy Abatement Scenario forecasts were greater than those of the Energy Scenario by 0.6 percent for GNP, 0.45 percent for total output and 200,000 employed civilians.

Table 23 presents various pollution control costs as a percentage of Energy Scenario GNP. Comparing these percentages with the values given in Table 6 and Table 14 again demonstrates the relative impact insensitivity to the range of assumptions provided in this macroeconomic analysis.

Table 21.
General Projections of the Energy Abatement Scenario (56).
1976-1985

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Population (Millions)	215.80	217.70	219.80	227.19	224.10	226.40	228.70	231.00	233.40	235.70
Labor Force (Millions)	95.40	97.00	98.60	100.20	101.80	103.20	104.50	105.70	106.70	107.70
Unemployment Rate (%)	6.10	5.00	4.00	4.10	4.60	4.60	4.50	4.20	4.00	4.00
Disposable Income Per Capita (1,000 1975 \$)	5.62	5.99	6.53	7.00	7.46	7.69	8.00	8.25	8.48	8.70
Gross National Product (Trillion 1975 \$)	1.59	1.70	1.81	1.92	2.02	2.09	2.16	2.23	2.30	2.37
Personal Consumption Expenditures	0.97	1.03	1.12	1.19	1.27	1.33	1.39	1.45	1.50	1.56
Investment	0.28	0.30	0.31	0.33	0.35	0.36	0.37	0.37	0.37	0.38
Government Expenditures	0.32	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42
Federal	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14
Other	0.20	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27	0.28
Total Output (Trillion 1975 \$)	2.67	2.87	3.07	3.25	3.44	3.56	3.68	3.81	3.94	4.07
Manufacturing	1.13	1.21	1.29	1.36	1.44	1.47	1.50	1.55	1.59	1.63
Total Energy Use (Trillion Btu's)	79.72	82.75	85.52	87.62	89.75	91.72	93.42	95.11	97.73	99.64
Natural Gas	19.41	19.35	19.79	20.06	20.32	20.48	20.62	20.84	21.12	21.29
Petroleum	30.21	30.66	31.16	31.38	31.61	31.85	31.96	32.22	32.45	32.58
Coal	4.80	5.14	5.27	5.44	5.58	5.67	5.73	5.84	5.95	6.07
Electricity	25.29	27.60	29.30	30.74	32.25	33.72	35.11	36.62	38.21	39.68
U.S. Demand (Million Metric Tons)										
Copper	2.45	2.72	2.85	2.99	3.08	3.11	3.16	3.22	3.27	3.33
Iron	147.30	157.38	158.00	163.86	167.81	167.47	165.21	165.32	165.69	166.77
Aluminum	4.87	5.32	5.56	5.91	6.22	6.36	6.44	6.58	6.72	6.87
Recycled Materials (Million Metric Tons)										
Paper	69.79	74.08	77.41	78.91	85.54	86.92	89.16	91.73	94.02	95.98
Aluminum	6.27	6.72	7.27	7.74	8.27	8.55	8.88	9.23	9.58	9.90
Ferrous Metals	1.39	1.55	1.59	1.72	1.90	2.05	2.06	2.15	2.24	2.27
\$R	42.19	44.47	45.80	47.41	48.99	50.08	51.19	52.42	53.36	54.14

Table 21. (Continued)
General Projections of the Energy Abatement Scenario (\$6).
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Vehicle Kilometers (Trillions)	1.49	1.54	1.61	1.67	1.80	1.85	1.92	1.96	1.99	2.03
Auto	1.47	1.53	1.59	1.65	1.78	1.82	1.89	1.93	1.96	2.00
Freight Metric Ton-Kilometers (Billions)	3.64	3.91	4.10	4.27	4.45	4.58	4.71	4.86	5.02	5.16
Truck	0.75	0.82	0.87	0.92	0.97	1.02	1.06	1.11	1.16	1.21
Rail	1.18	1.25	1.31	1.35	1.40	1.44	1.47	1.51	1.55	1.58
Net Air Residuals (Million Metric Tons)										
Particulates	15.47	9.29	9.43	9.73	10.02	10.19	9.31	8.46	7.53	6.59
Sulfur Oxides	18.99	14.23	14.90	15.43	15.99	16.28	16.40	16.61	16.84	17.01
Nitrogen Oxides	18.05	19.23	20.09	20.69	21.30	21.58	22.04	22.42	22.70	22.96
Hydrocarbons	9.39	8.79	8.62	8.33	8.06	7.68	7.11	6.53	6.05	5.54
Carbon Monoxide	53.70	50.70	48.71	45.84	43.01	39.31	35.22	32.16	29.00	26.85
Net Water Residuals (Million Metric Tons)										
Biochemical Oxygen Demand	2.95	2.11	1.66	1.68	1.71	1.57	1.44	1.29	1.13	1.11
Suspended Solids	7.06	4.68	2.71	2.69	2.76	2.41	2.03	1.64	1.23	1.18
Dissolved Solids	11.51	11.47	11.48	11.82	12.16	11.18	10.25	9.44	8.70	8.90
Nutrients	1.33	1.24	1.18	1.13	1.07	1.02	0.96	0.90	0.84	0.78
Air Control Costs (Billion 1975 \$)	9.10	11.93	17.62	15.26	13.49	13.29	12.99	12.95	12.99	13.20
Investment										
Annualized Costs										
Capital	9.45	11.42	15.01	17.98	20.41	22.53	24.35	25.87	27.16	28.18
O&M	9.60	9.43	9.26	9.59	9.73	9.70	9.59	9.42	9.30	9.19
Capital in Place	43.15	51.75	64.71	74.47	81.63	87.82	92.93	97.24	100.81	103.82
Direct Employment (Thousands)	15	17	19	21	21	21	21	21	20	20
\$R										

Table 21. (Continued)
General Projections of the Energy Abatement Scenario (\$6),
1976-1985
\$t

Statistics	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Water Industrial Costs (Billion 1975 \$)										
Investment	5.02	7.26	4.83	6.92	7.87	7.10	6.59	5.23	1.34	1.54
Annualized Costs										
Capital	2.17	3.08	3.67	4.52	5.51	6.39	7.25	7.93	8.08	8.27
O&M	3.67	4.88	5.93	6.44	6.84	7.18	7.41	7.72	10.94	11.38
Capital in Place	16.89	24.14	28.92	35.78	43.59	50.63	57.16	62.32	63.52	64.92
Direct Employment (Thousands)	115	153	187	204	218	230	239	250	368	385
Water Municipal Costs (Billion 1975 \$)										
Investment	6.55	8.11	8.13	5.59	2.94	1.77	0.80	0.70	0.70	0.53
Annualized Costs										
Capital	2.27	3.17	4.06	4.68	5.00	5.20	5.28	5.36	5.44	5.50
O&M	0.68	0.93	1.36	1.61	1.76	1.84	1.89	1.93	1.97	2.00
Capital in Place	20.63	28.74	36.88	42.47	45.41	47.17	47.97	48.67	49.37	49.90
Direct Employment (Thousands)	20	27	40	48	52	54	56	57	58	59

Includes state transportation control costs and mobile source pollution abatement expenditures.

Annualized to include interest on all investments, including those for mobile source controls.\$s\$R

Table 22.
Comparison of the Macro Statistics of the Energy Abatement
Scenario (S6) and the Energy Scenario (S5)
[(S6-S5)/S5 in %]

Statistic	1975	1977	1980	1983	1985
Gross National Product	2.12	1.97	0.16	0.18	0.06
Disposable Income Per Capita	0.00	0.00	-1.06	-0.82	-0.86
Federal Expenditures	0.24	1.06	2.25	2.19	2.16
Personal Consumption Expenditures	0.64	0.45	-0.68	-0.31	-0.27
Unemployment Rate					
Total Output	2.53	2.37	0.44	0.46	0.45
Manufacturing	3.21	2.90	0.71	0.58	0.51
Investment	7.99	6.15	2.23	1.15	0.53
Energy Use	4.22	4.27	3.40	3.22	4.12
Demand: Iron	4.56	3.89	-0.45	-1.26	-1.46
Aluminum	3.71	3.50	0.65	0.30	0.14
Recycling: Paper	0.79	0.72	-0.60	-0.29	-0.17
Aluminum	2.46	2.19	0.42	0.30	0.40
Ferrous Metals	1.89	1.71	0.35	0.42	0.81
Vehicle Kilometers Travelled	0.00	0.00	-0.98	-0.87	-2.47
Freight Ton-Kilometers	3.90	3.56	1.58	1.55	1.64
Net Air Residuals:					
Particulates	-42.63	-80.92	-81.35	-84.29	-87.34
Sulfur Oxides	-32.68	-63.66	-62.76	-62.37	-61.53
Nitrogen Oxides	-1.56	-2.70	-6.85	-10.60	-11.35
Hydrocarbons	-17.29	-27.62	-40.53	-50.65	-63.11
Carbon Monoxide	-23.49	-33.37	-53.16	-65.52	-75.29
Net Water Residuals:					
Biochemical Oxygen Demand	-22.38	-59.66	-71.12	-79.52	-83.05
Suspended Solids	-17.70	-60.65	-78.66	-87.27	-90.68
Dissolved Solids	-0.84	-9.15	-14.92	-35.20	-39.41
Nutrients	-9.94	-22.58	-35.66	-47.90	-55.85

Table 23.
Pollution Control Costs as a
Percentage of Energy Scenario GNP

\$t	1977	1980	1983	1985	1976-85
Air					
Stationary Source Costs					
Capital Costs	0.33	0.08	0.03	0.03	0.12
O&M Costs	0.25	0.26	0.24	0.23	0.25
Water					
Industrial Costs					
Capital Costs	0.43	0.39	0.23	0.07	0.27
O&M Costs	0.29	0.34	0.35	0.48	0.36
Water Municipal					
Costs					
Capital Costs	0.49	0.15	0.03	0.02	0.18
O&M Costs	0.06	0.09	0.09	0.08	0.08\$R

The effects of the energy conservation assumptions on environmental residuals are provided as annual average treatment efficiencies in Tables 24 and 25. These values again show little variation in efficiencies, although the changes are greater here than in the Reference Abatement and Low Productivity Abatement Scenarios. This difference results primarily from the greater variability introduced into the interindustry flows by the energy conservation measures.

Thus, for the two major scenario variations, level of economic activity and level of energy usage, the difference at the macroeconomic level between the scenarios without

abatement effects and with Federal pollution control regulation effects appear quite similar.

Table 24.
Relative Stationary Source Treatment Efficiencies
of Selected Pollutants for the Energy Abatement Scenario,
1975, 1980 and 1985

\$t	1975	1980	1985
Particulates	77.4%	93.9%	55.2%
Sulfur Oxides	52.3%	73.9%	73.2%
Nitrogen Oxides	2.5%	5.6%	5.7%
Hydrocarbons	49.8%	58.4%	69.1%
Carbon Monoxide	55.2%	63.1%	64.0%
Biochemical Oxygen Demand	74.4%	90.2%	94.3%
Suspended Solids	84.3%	96.0%	98.3%
Dissolved Solids	33.7%	44.2%	61.8%
Nutrients	35.1%	56.5%	71.3%\$R

Table 25.
Transportation Emissions Levels for the
Energy Abatement Scenario
(Metric Tons per Million Vehicle Kilometers Travelled)

\$t	1975	1980	1985
Particulates	0.51	0.51	0.55
Sulfur Oxides	0.45	0.50	0.55
Nitrogen Oxides	6.14	6.04	5.60
Hydrocarbons	4.45	2.57	1.37
Carbon Monoxide	34.11	20.38	8.85\$R

\$aChapter 4 Sectoral Analyses Results\$R

The following discussion analyzes the results of the Reference Abatement Scenario at the sectoral level. Estimated reductions in pollutant residuals derived from the Reference Abatement Scenario are analyzed for industries, mobile sources, municipal treatment, and Federal, state, and local governments. After this, an analysis is performed of the sectoral costs forecast for industries to comply with Federal pollution control legislation.

\$bESTIMATING THE REDUCTION IN AIR RESIDUAL GENERATION\$R

The graphs in Figure 1 show the impacts of the Reference Abatement Scenario in terms of air residual generation. In the graphs, the net (controlled) residual emission for 1971 is set equal to 100 and each subsequent year is indexed to 1971 controlled emissions. Uncontrolled emissions are also shown indexed to 1971 controlled emissions. The difference between the two plots indicate the effectiveness of the overall pollution abatement technology for that pollutant in the forecast year. Controlled emissions are defined to be

those that enter the receiving media (air, water) from the generating source after the abatement process. The relative contribution to total controlled emissions in air by industrial/commercial sources, electric utilities and municipal treatment is shown by the area between the appropriately labeled curves.

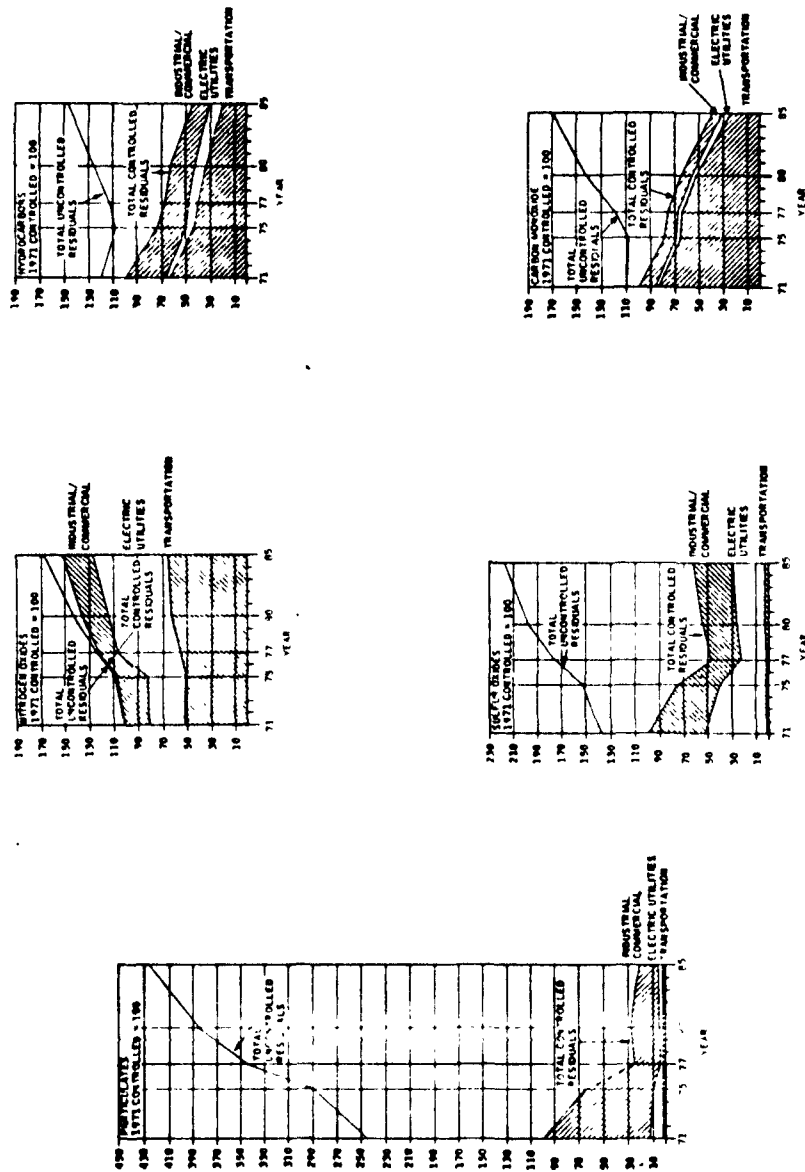
Reduction in residuals discharged to the nation's environment is only a gross indicator of environmental quality. However, significant increases or decreases of the various types of emitters are indicative since in many cases industrial sectors are concentrated in certain geographic regions.

\$bEstimating Air Residuals\$R

Particulates and sulfur dioxide emissions result primarily from activity in the stationary sources (industrial/commercial and electric utilities) while the major source of hydrocarbons is from mobile sources (transportation). Nitrogen oxide emissions are approximately equal from the fixed and mobile sources in 1971, and it is shown to be a difficult pollutant to abate.

Figure 1.
Trends in Air Pollutants from 1970 Reference
Abatement Scenario

244
245
246



For the stationary-source residuals (particulates and sulfur dioxide), decreasing controlled emissions are shown until 1977. The end of 1977 was chosen in the Reference Case Scenarios to be the date that full compliance to the Clean Air Act for fixed sources occurs. After 1977, the plots level and show slight increases to 1985, approximating a growth in economic activity without a subsequent increase in pollution abatement efficiencies for these sources. There is a slight dampening in the growth of the controlled emissions from these sources compared with the economic growth over the same period due to more stringent controls on new plant sources. The relative contributions to the controlled emissions for particulates show the mobile sources share to be approximately 2 percent from 1971 through 1985; the relative contribution to the total from industrial/commercial sectors decreases from 87 percent in 1971 to 17 percent in 1985; electric utilities shares remain fairly constant (3 percent) throughout the forecast period. The relative contributions to sulfur oxides controlled emissions show the mobile source share increasing from 2 percent in 1971 to 3 percent in 1985. Contributions from the industrial/commercial source remains fairly constant throughout the interval, decreasing slightly by 1985, while the electric utilities share decreases by approximately 25 percent from 1971 to 1985.

The graph for controlled hydrocarbon emissions shows a steady decrease to 1985. Hydrocarbon emissions standards for automobiles are scheduled for full compliance in 1978. The steady decrease in the hydrocarbon graph is due to the phaseout of the older model-year cars from the total of cars still on the road; older cars are not so well controlled as newer models. This tends to offset the increase in controlled emissions from both industrial/commercial and electric utilities emissions after 1977.

The uncontrolled hydrocarbon emissions show a decrease from 1971 to 1975, because older automobiles (pre-1968 model years) had hydrocarbon emission factors approximately 120 percent larger than those for 1971 model year; these cars were still "on the road" in 1971 and are phased out throughout the forecast period. The mobile sources share of hydrocarbons decreases from 63 percent in 1971 to 20 percent in 1985 with a concomitant increase from the fixed sources.

Nitrogen oxides uncontrolled emissions increased 25 percent throughout the forecast period. The electric utilities contribution increased from 30 to 62 percent, while the mobile source share increased from 53 percent to 65 percent; the remainder from industrial/commercial sources is fairly constant. The forecasted increase in nitrogen oxide controlled emissions due to mobile sources is exaggerated in

this forecast because at the present time, an adequate technology is not available for meeting the 1979 standard. This implies the increase in nitrogen oxide emissions would be even more severe if the 1979 standard is modified or not met.

Table 1 shows the largest contributors to the industrial/commercial share of controlled emissions for the air residuals. The combustion of fossil fuels by 1985 supplies the largest proportion of sulfur oxide and nitrogen oxide emissions. Asphalt production and Crude Oil Refining have the largest share of particulates and sulfur oxides respectively in 1971; but, because of improved treatment efficiencies, they make small contributions to the sum in 1985. The consumption of gasoline at service stations and the production and use of solvent-based paints dominate the generation of controlled hydrocarbon emissions in 1971 and increase their shares by 1985; the production and consumption of Solvent-Based Paints yield over 60 percent of the industrial/commercial share of hydrocarbons and over 25 percent of the total controlled hydrocarbon emissions in 1985.

Differences in air residuals as forecast in the Low Productivity and Energy Abatement Scenarios are presented in Table 2 as percent changes from the major polluting

industries forecast in the Reference Abatement Scenario. For the Low Productivity Scenario one would expect these differences to be on the order of the percent change in GNP, as shown at the bottom of the table. The general tendency, however, is for residual production to change at a lower rate than GNP, with the notable exception of the industrial and commercial use of fossil fuels. As expected, little difference is seen between the Energy Conservation and the Reference Abatement Scenarios other than in the energy related sectors, where significantly lower residuals are forecast for the Energy Conservation case.

Table 1.
Industrial/Commercial Air Residuals by
Largest Contributing Sectors/Subsectors

\$t	Percent of Industrial and Elec. Emissions from Reference Abatement Scenario			
Sectors/Subsectors	1971	1975	1980	1985
Particulates				
Stone & Clay Products Crushed Stone	17.5	26.7	62.8	37.6
Paving & Asphalt Asphalt	12.5	10.0	2.8	3.3
Cement, Concrete, Gyphs. Cement-Dry Grinding	12.3	10.9	2.8	4.8
Cement-Wet Grinding	11.3	10.0	2.6	4.4
Electric Utilities Elec. by Coal	10.5	9.7	3.5	6.3
Steel	6.5	6.3	3.4	4.6
Cement, Concrete, Gyphs. Lime	3.4	2.8	0.6	1.0
Industrial Combustion of Coal N.E.C.	2.6	1.9	0.8	1.4
Sulfur Oxides				
Electric Utilities Elec. by High Sulfur Coal	46.3	42.3	26.5	24.1
Petroleum Refining Crude Oil Refining	7.5	4.6	0.6	0.7
Crude Petro. Nat. Gas Sour Nat. Gas Proc. Plants	4.4	2.5	0.1	0.1
Petroleum Refining-Ind. Combustion of Oil	4.2	6.3	11.0	11.9
Commercial/Institutional Use of Residual Oil	3.8	5.3	10.6	11.8

Table 1. (Continued)
Industrial/Commercial Air Residuals by
Largest Contributing Sectors/Subsectors

	\$t			
	Percent of Industrial and Elec. Emissions from Reference Abatement Scenario			
Sectors/Subsectors	1971	1975	1980	1985
Electric Utilities Elec. by High Sulfur Residual Oil	3.2	2.9	2.2	2.5
Electricity by Low Sulfur Coal	0.8	4.4	12.0	14.4
Nitrogen Oxides				
Electric Utilities Elec. by Coal	41.6	48.1	50.7	50.4
Elec. by Gas	10.8	8.1	5.5	5.4
Elec. by Oil	8.9	11.3	13.5	14.8
Petroleum Refining Industrial Combustion Of Oil	3.8	3.2	2.5	2.5
Hydrocarbons				
Service Stations Gasoline Consumption	17.3	25.7	29.4	24.5
Paints Solvent Base Paints Production	16.9	22.1	26.1	33.1
Open Burning Solvent Based Paints Consumption	10.3	0	0	0
	10.1	10.6	9.8	11.1
Petroleum Refining Crude Oil Refining Gasoline Production	8.5	5.6	2.2	3.1
	6.8	7.0	5.7	8.4
Industrial Chemicals Ethylene Oxide	3.2	2.0	0.4	0.5
GNP (Trillions 1975\$)	1.36	1.50	2.02	2.37\$R\$S

Table 2
Percent Changes in Air Residuals from
Alternative Abatement Scenarios S4 and S6
Compared with the Major Polluting Industries
from the Reference Abatement Scenario (S2)
\$t

Sector/Subsector	Percent Difference from the Reference Abatement Scenario					
	Low Productivity 1971	1975	1980	Abatement (S4) 1985	1971	Energy Abatement (S6) 1975 1980 1985
Particulates						
Stone & Clay Products Crushed Stone	0.0	3.2	-7.8	-9.1	0.0	-0.1 -0.4 -0.5
bpaving & Asphalt Asphalt	0.0	2.8	-6.8	-8.5	0.0	-0.1 -0.2 -0.3
Cement, Concrete, Gypsum Cement-Dry Grinding Cement-Wet Grinding	0.0 0.0	3.4 3.4	-8.5 -8.5	-9.5 -9.5	0.0 0.0	-0.2 -0.2 -0.4 -0.5
Electric Utilities Electricity by Coal	0.0	2.0	-4.9	-9.0	0.0	-1.7 -5.4 -14.0
Steel	0.0	0.1	-9.7	-10.2	0.0	-2.1 -0.4 -2.1
Cement, Concrete, Gypsum Lime	0.0	3.2	-8.6	-10.2	0.0	-0.2 -0.3 -1.5
Industrial Combustion of Coal N.E.C.	0.0	4.4	-8.4	-12.2	0.0	0.0 0.1 0.1
Sulfur Oxides						
Electric Utilities Electricity by High Sulfur Coal	0.0	2.0	-4.9	-9.0	0.0	-1.7 -5.4 -14.0
Petroleum Refining Crude Oil Refining	0.0	2.1	-4.8	-6.6	0.0	-7.4 -7.3 -14.5
Crude Petroleum, Natural Gas Sour Natural Gas Proc. Plants	0.0	1.6	-3.4	-5.5	0.0	-0.5 -3.3 -4.1
Petroleum Refining Industrial Combustion of Oil	0.0	2.1	-4.8	-6.6	0.0	-7.4 -7.3 -14.5
Commercial/Institutional Use of Residual Oil	0.0	4.6	-7.8	-13.2	0.0	0.2 0.3 0.7

Table 2 (Continued)
Percent Changes in Air Residuals from
Alternative Abatement Scenarios S4 and S6
Compared with the Major Polluting Industries
from the Reference Abatement Scenario (S2)

Sector/Subsector	Percent Difference from the Reference Abatement Scenario				
	Low Productivity Abatement (\$4)		Energy Abatement (\$6)		
	1971	1975	1980	1985	1985
Electric Utilities					
Electricity by High Sulfur Residual Oil	0.0	2.0	-4.9	-9.0	-14.0
Electricity by Low Sulfur Oil	0.0	2.0	-4.9	-9.0	-14.0
Nitrogen Oxides					
Electric Utilities					
Electricity by Coal	0.0	2.0	-4.9	-9.0	-14.0
Electricity by Gas	0.0	2.0	-4.9	-9.0	-14.0
Electricity by Oil	0.0	2.0	-4.9	-9.0	-14.0
Petroleum Refining					
Industrial Combustion of Oil	0.0	2.1	-4.8	-6.6	-14.5
Hydrocarbons					
Service Stations					
Gasoline Consumption	0.0	0.7	-2.0	-3.0	-36.7
Paints					
Solvent Base Paint Production	0.0	3.9	-7.8	-11.6	0.3
Open Burning	0.0	0.0	0.0	0.0	0.0
Solvent Based Paints Consumption	0.0	2.8	-5.1	-8.2	0.3
Petroleum Refining					
Crude Oil Refining	0.0	2.1	-4.8	-6.6	-14.5
Gasoline production	0.0	0.7	-2.0	-3.0	-36.7
Industrial Chemicals					
Ethylene Oxide	0.0	6.4	-10.3	-13.4	-0.7
GNP (Trillions 1975\$)	0.0	13.94	-8.39	-11.68	0.25
\$R\$					

\$bEstimating Water Residuals\$R

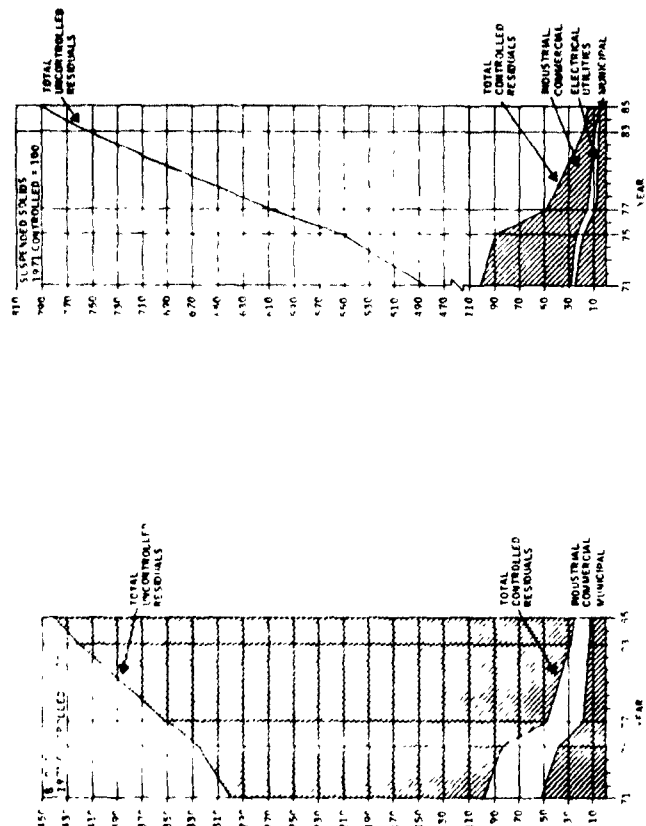
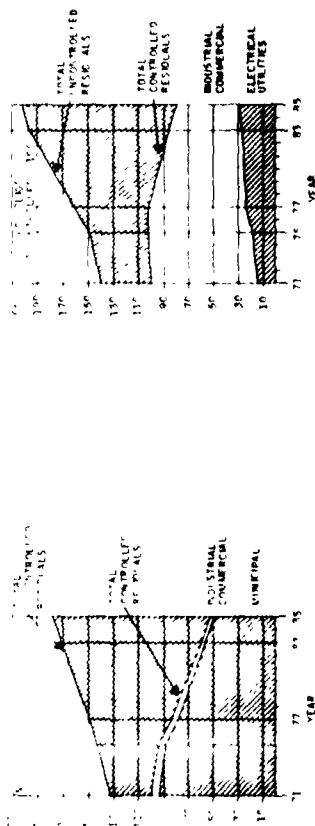
The shape of the total controlled water residual curves (see Figure 2) does not show an increase after 1977 similar to the total controlled air residual curves for particulates and sulfur oxides. This is due primarily to the phased abatement schedule for water effluents in the 1972 amendments. The Reference Abatement Scenario assumes that BPT is operational by 1977 and the BAT is utilized by 1983; therefore, there is a continual increase in most water effluent removal efficiencies until 1983.

The curves for the total uncontrolled residuals for water show trends similar to the air residual curves, responding to increases in economic activity and population.

Industrial/commercial and municipal sewage comprise the two largest contributors to BOD effluents. They continue yielding equal shares through 1985. All three sources contribute to suspended solids controlled emissions. In 1971, the industrial/commercial share was approximately 75 percent; however, by 1985 its share diminishes to less than 50 percent with municipal sewage increasing from 24 percent in 1971 to over 50 percent in 1985.

2501
2502
2503

Figure 2.
Trends in Water Residuals from the
Reference Abatement Scenario



The composition of the dissolved solids effluents is almost totally (85 percent) from industrial/commercial sources in 1971; by 1985 the industrial/commercial source has 50 percent of the dissolved solids effluents while the electric utilities share grows from 15 percent to 30 percent. primarily due to electric generation by coal. Nutrients (composed of phosphate and nitrate effluents) are almost totally due to municipal sources.

Table 3 shows the largest economic sector and subsector contributors to the industrial/commercial controlled effluents for water. In 1985, Forestry and Fishery products has the largest share of 800 controlled effluents. Asphalt production and Bauxite Refining process were the largest polluters of suspended solids for industrial/commercial sources in 1971. The Industrial Chemicals sector yields the greatest share of dissolved solids effluents. Of these, the production of sodium carbonate by the Solvay process was the largest contributor in 1971. This economic production process, however, is later replaced by a competing process for the production of sodium carbonate, the Trona process. The Trona process yields negligible water residuals; therefore, its effluents significantly decrease to essentially 0 percent in 1985. The share for Citric Acid production increases from about 25 percent to over 51 percent of industrial/commercial suspended solids effluents.

The production of Citric Acid increases to double the 1971 value by 1985.

Table 4 presents the percent differences in water residuals forecast in the Low Productivity and Energy Abatement Scenarios as compared with the major water pollutants from the Reference Abatement Scenario. The same general trends between scenarios are evidenced for water residual differences as for air residuals.

Table 3.
Industrial/Commercial Water Residuals by
Largest Contributing Sectors/Subsectors

Sectors/Subsectors	1971	1975	1980	1985
Percent of Industrial and Elec. Emissions from Reference Abatement Scenario				
Biochemical Oxygen Demand				
Pulp Mills				
Kraft-Bleached	13.0	11.1	7.4	6.7
Forestry & Fishery Products	7.4	14.5	33.3	40.4
Plastic Materials & Resins	7.1	11.3	10.3	6.6
Pulp Mills				
Sulfite-Pulp	6.0	5.4	3.5	2.5
Pulp Mills				
Kraft-Unbleached	5.5	5.6	5.8	5.8
Suspended Solids				
Paving & Asphalt				
Asphalt	24.6	17.7	0	0
Aluminum				
Bauxite Refining	21.2	15.9	0	0
Steel	16.2	17.0	13.2	6.7
Cement. Concrete Gyps. Lime	6.7	1.6	7.2	11.9
Pulp Mills				
Kraft-Bleached	4.2	6.5	10.1	9.7
Forestry & Fishery Products	3.7	9.0	15.3	12.3\$R

Table 3. (Continued)
Industrial/Commercial Water Residuals by
Largest Contributing Sectors/Subsectors

Sectors/Subsectors	1971	1975	1980	1985
Percent of Industrial and Elec. Emissions from Reference Abatement Scenario				
Dissolved Solids				
Industrial Chemicals				
Sodium Carbonate- Solvay Process	41.3	30.5	7.6	0
Citric Acid	24.4	27.8	45.5	51.0
Electric Utilities				
Electricity by Coal	15.0	24.8	32.1	35.2
Industrial Chemicals				
Chlorine-Diaphragm Cell	2.5	3.6	1.5	0
GNP (Trillion 1975\$)	1.36	1.69	2.23	2.375R

Table 4
Percent Changes from Water Residuals
from Alternative Abatement Scenarios S4 & S6
Compared with the Major Polluting Industries
from the Reference Abatement Scenario (S2)

\$t

Sector/Subsector	Percent Difference from the Reference Abatement Scenario							
	Low Productivity Abatement (S4)				Energy Abatement (S6)			
	1975	1977	1983	1985	1975	1977	1983	1985
Biochemical Oxygen Demand								
Pulp Mills Kraft-Bleached	0.0	1.1	-8.8	-10.2	0.0	0.5	-0.8	-1.7
Forestry & Fishery Products	0.0	1.4	-15.2	-17.4	0.0	0.2	-0.1	0.0
Plastic Materials & Resins	0.0	1.3	-10.2	-11.6	0.0	-0.2	-2.2	-3.5
Pulp Mills Sulfite-Pulp	0.0	1.3	-8.3	-9.7	0.0	0.3	0.3	0.3
Pulp Mills Kraft-Unbleached	0.0	1.1	-8.8	-10.2	0.0	0.6	-0.8	-1.7
Suspended Solids								
Paving & Asphalt Asphalt	0.0	0.9	0	0	0.0	0.0	0	0
Aluminum Bauxite Refining	0.0	1.3	0	0	0.0	0.0	0	0
Steel	0.0	0.7	-9.8	-9.3	0.0	0.0	-0.7	0.6
Cement, Concrete, Gypsum Lime	0.0	1.1	-9.0	-10.2	0.0	0.0	-1.0	-1.5
Pulp Mills Kraft-Unbleached	0.0	1.1	-8.8	-10.2	0.0	0.6	-0.8	-1.7
Forestry & Fishery Products	0.0	1.4	-15.2	-17.4	0.0	0.2	-0.1	0.0

Table 4. (Continued)
Percent Changes from Water Residuals
from Alternative Abatement Scenarios S4 & S6
Compared with the Major Polluting Industries
from the Reference Abatement Scenario (S2)

\$t

Sector/Subsector	Percent Difference from the Reference Abatement Scenario							
	Low Productivity Abatement (S4)				Energy Abatement (S6)			
	1975	1977	1983	1985	1975	1977	1983	1985
Dissolved Solids								
Industrial Chemicals								
Sodium Carbonate-								
Solvay Process	0.0	1.2	-10.1	0	0.0	-0.1	-1.2	0
Citric Acid	0.0	2.3	-10.7	-12.9	0.0	0.3	0.9	1.3
Electric Utilities								
Electricity by Coal	0.0	0.9	-7.4	-9.0	0.0	-3.5	-9.4	-14.0
Industrial Chemicals								
Chlorine-Diaphragm Cell	0.0	1.4	-10.1	0	0.0	0.0	-0.9	0
GNP (Trillion 1975\$)	0.0	+0.28	-10.39	-11.68	0.0	0.27	0.22	0.25
\$R\$								

\$BESTIMATING THE COST OF
POLLUTION CONTROL\$R

Assuming air and water pollution controls and cost functions and the CEA/BLS growth in GNP, direct costs of pollution control for each industry sector can be calculated using the SEAS system. The total annual costs (annualized capital plus O&M) for the 1976-85 period for industries is.

Industrial Control Costs (Billions 1975\$)	\$233.8
Air Costs	\$112.3
Water Costs	\$121.5

These costs are borne by the aggregate industrial sectors as shown in Table 5 (1975 dollar levels and percentage of national totals); note that Electric Power Plants must make about a fourth of the air pollution costs. Nearly another quarter of the air costs are borne by many different industries to provide space heating (the major aggregate industries making this expenditure are Chemicals and Paper).

By far the largest water pollution control expenditure is made by the Machinery and Equipment sector (this includes electroplating, fabricated metal products, and electrical and nonelectrical machinery). The Chemicals sector is the

second largest spender for water pollution control (in particular, Organic Chemicals, Inorganic Chemicals, and Plastics and Synthetics).

\$dTable 5.
 Annualized National Control Costs for Air and Water
 Pollution Abatement (excluding Transportation Control Costs), 1976-1985
 (In Millions of 1975 Dollars)

\$t	-----AIR-----			-----WATER-----			---AIR & WATER---		
	Total Costs	% of National Costs	Total Costs	% of National Costs	Total Costs	% of National Costs			
Aggregated Industrial Sectors									
Agriculture	0	0	291	0.24	291	0.12			
Mining	588	0.52	0	0	588	0.25			
Food Processing	3,343	2.98	6,626	5.45	9,969	4.26			
Textiles	0	0	1,180	0.97	1,180	0.50			
Pulp, Paper, & Lumber	7,911	7.04	8,054	6.63	15,965	6.83			
Chemicals	2,724	2.42	19,832	16.33	22,557	9.65			
Petroleum & Rubber	1,931	1.72	2,416	1.99	4,347	1.86			
Ferrous Metals	10,128	9.02	8,287	6.82	18,415	7.88			
Nonferrous Metals	11,210	9.98	1,547	1.27	12,757	5.46			
Stone, Clay, & Glass	7,193	6.40	389	0.32	7,582	3.24			
Machinery & Equipment	3,651	3.25	65,580	53.99	69,231	29.61			
Electric Utilities	24,538	21.84	7,266	5.98	31,804	13.60			
Solid Waste & Incineration	7,043	6.27	0	0	7,043	3.01			
Trade & Services	3,652	3.25	0	0	3,652	1.56			
Space Heating	28,420	25.30	0	0	28,420	12.16			
National Totals	112,332		121,468		233,801				

Note: Totals may not sum due to rounding.\$R\$\$s

To illustrate the components of the cost estimates for each industry, two of the aggregate industrial sectors (Paper and Printing and Ferrous Metals) are examined in greater detail. Table 6 shows the three sectors that comprise Paper and Printing and the four sectors that comprise Ferrous Metals. Note that Kraft Pulping comprises greater than 85 percent of the air pollution control expenditures for the aggregate Paper and Printing sectors. The manufacture of iron and steel, similarly, comprises the bulk of the Ferrous Metals expenditures for air pollution control.

Table 6.
Air Pollution Industrial Detail for
Paper and Ferrous Metals

\$t	% of Total Annual Air Expenditures (1971-85)
Paper and Printing	7.0
Kraft Pulp	6.1
NSSC Pulp	0.8
Printing	0.1
Ferrous Metals	9.4
Iron and Steel	6.4
Iron Foundries	2.0
Steel Foundries	0.5
Ferroatloys	0.6\$R

Kraft Pulping expenditures for air pollution control are calculated using 10 industrial segments. The expenditures for Iron and Steel manufacture are calculated using 22 industrial segments. The 10 segments and their contribution to the Kraft Pulping total are shown in Table 7.

Table 7.
Air Pollution Segment Detail for Kraft Pulping

\$t	% of Total Annual Air Expenditures
Paper	
Kraft Pulping	6.1
Lime Kiln	0.10
Smelting Tank	0.08
Gas Incineration in Recovery Furnace	0.10
Gas Incineration in Lime Kiln	0.10
Boiler--TSP	0.28
Boiler--SOx	3.53
Recovery Furnace	
Scrubber	0.03
Black Liquor Oxidation	0.28
Replacement	1.03
Electrostatic Precipitator	0.57\$R

SCINDUSTRY INVESTMENT\$R

The difficulty that industries face making the pollution control expenditures are dependent upon many factors. One of these factors is the size of the pollution investment required as a percentage of the total expected investment by that industry. Considering air expenditures, the Feed Mill industry will have to make a 14.5 percent addition in total investment during the 1976-85 period if it is to adequately control air pollution. Other industries with large air pollution investment requirements relative to total investment requirements are: Electric Utilities (6.3 percent), Nonferrous Metals (6.0 percent), Petroleum (5.4

percent), Paper (5.1 percent) Ferrous Metals (4.7 percent), and Asbestos, Clay and Concrete (3.0 percent).

Although these are interesting statistics, a more useful one might be to compare the increased investment cost as a percent of total output.

The total annual air pollution control costs during the 1976-85 period as a percent of the total output value of the sector is much smaller than the above ratios. The highest annual cost ratio is: Paper (3.21 percent), Electric Utilities (3.16 percent), Nonferrous Metals (2.70 percent), Ferrous Metals (2.61 percent) Asbestos, Clay and Concrete (1.76 percent), and Feed Mills (1.75 percent).

Similar statistics on water pollution abatement investment to total investment over the decade provide the following industry ranking:

Leather Tanning	69.3%
Fabricated Metals & Electroplating	22.1%
Canned & Frozen Food	15.7%
Chemicals	10.7%
Pulp & Paper	10.6%
Dairy	9.6%
Meat & Poultry	7.9%
Machinery	7.7%
Plastics and Synthetics	7.6%

Other industries are impacted at less than 6 percent for this statistic.

The ratio of total industrial plant expenditures (not including payments to municipalities for water pollution control to total output show much smaller percentages. The highest impacted industries for this statistic are:

Fabricated Metals &	
Electroplating	5.3%
Leather Tanning	4.5%
Chemicals	3.3%
Pulp & Paper	2.1%
Canned & Frozen Food	1.8%
Iron & Steel	1.6%

All other industries are impacted less than 1.5 percent.

The final consideration is the total impact of the combination of air and water pollution control costs. Altogether, ten of the aggregate industries will require an investment level for pollution control over the decade that is more than 10 percent of the total expected investment for the industry.

Leather Tanning	69.3%
Fabricated Metals &	
Electroplating	22.1%
Machinery	16.9%
Canned & Frozen Food	15.7%
Pulp & Paper	15.6%
Grain Milling & Feed Mills	15.3%
Chemicals	10.7%

Electric Utilities	10.5%
Petroleum & Asphalt	10.2%

All industries have a total control cost as a percentage of output of less than 5.4 percent. The most severely affected are:

Fabricated Metals & Electroplating	5.3%
Pulp & Paper	5.3%
Iron & Steel	4.2%
Electric Utilities	4.1%
Chemicals	4.0%
Nonferrous Metals	3.1%

The other industries are impacted at less than 2 percent of their total decade output.

Complete listings of the data for the aggregate sectors are presented in Table 8 (Expenditures) and Table 9 (Investment).

Table 10 ranks the top 20 impacted industries in terms of air, water, and combined expenditures. Relative impacts are shown both as pollution control investment relative to total investment and total pollution control expenditures relative to total industry output.

Of the 31 industrial categories, thirteen require abatement expenditures for both air and water. Industries with high air pollution expenditure control costs often have significant water costs as well. Industries with high water

pollution expenditure control costs are less likely to also have air control expenditures. Industries having high pollution investment costs also have high O&M costs.

Of the 31 industries, eight require investment fractions for pollution control over the decade to be above 10 percent, with Leather Tanning spending more than two-thirds of its investment dollars for pollution control.

Water pollution control investments dominate the air pollution equipment investments. Of the 10 largest investors, four have water investments only, and two are heavy towards water. Of the other four, two are about even with two heavy in air pollution investment.

The investment patterns show similar patterns to the O&M cost patterns. Of the top 10 industries for air pollution control investments, nine also must make water pollution control investments; however, five of the top 10 industries for water pollution investment must also make air pollution control investments.

\$Table 8.
Relative Impacts of Total Decade In-House Expenditures,
1976-1985

Category	Output	Air		Water		Air & Water	
		Total Cost	% of Output	Total Cost	% of Output	Total Cost	% of Output
Agriculture (Beef Cattle							
Feedlots)	1,217,609	0	0	291	0.02	291	0.02
Mining	294,452	165	0.06	0	0	165	0.06
Natural Gas Processing	238,961	423	0.18	0	0	423	0.18
Meat & Poultry	484,157	0	0	1,421	0.29	1,421	0.29
Dairy	186,596	0	0	1,354	0.73	1,354	0.73
Canned & Frozen Food	198,237	0	0	3,525	1.78	3,525	1.78
Grain Milling, Feed Mills	192,854	3,379	1.75	202	0.10	3,581	1.86
Beet & Cane Sugar	50,022	0	0	126	0.25	126	0.25
Textiles	640,115	131	0.02	658	0.10	789	0.12
Lumber & Wood Products	175,754	0	0	422	0.24	422	0.24
Furniture	210,433	1,850	0.88	0	0	1,850	0.88
Pulp & Paper	362,221	11,628	3.21	7,427	2.05	19,055	5.26
Builder's Paper	136,103	0	0	206	0.15	206	0.15
Printing	304,739	111	0.04	0	0	111	0.04
Chemicals	493,666	3,154	0.64	16,502	3.34	19,656	3.98
Fertilizers	83,598	512	0.61	359	0.43	871	1.04
Plastics & Synthetics	219,851	152	0.07	2,972	1.35	3,124	1.42
Petroleum & Asphalt	619,735	7,953	1.28	2,416	0.39	10,369	1.67
Paints	57,928	120	0.21	0	0	120	0.21
Rubber Products	181,747	0	0	245	0.13	245	0.13
Leather Tanning	14,483	0	0	658	4.54	658	4.54
Glass	108,675	0	0	207	0.19	207	0.19
Asbestos, Clay, Lime, &							
Concrete	270,237	4,758	1.76	182	0.07	4,940	1.82
Iron & Steel	534,315	13,962	2.61	8,287	1.55	22,249	4.16
Nonferrous Metals	415,595	11,210	2.70	1,547	0.37	12,757	3.07
Fabricated Metals &							
Electroplating	609,177	0	0	32,258	5.30	32,258	5.30
Machinery	2,019,269	344	0.02	21,617	1.07	21,961	1.09
Transportation Equipment	1,736,639	902	0.05	11,705	0.67	12,607	0.73
Steam Electric	777,606	24,538	3.16	7,266	0.93	31,804	4.09
Wholesale & Retail (Grain							
Handling)	4,647,739	3,347	0.06	0	0	3,347	0.07
Services (Dry Cleaning)	7,132,453	305	0.01	0	0	305	0.01
Other Industries	N.A	18,318	N.A	0	N.A	18,318	N.A
Totals		N.A 107,262	N.A	123,161	N.A	230,423	N.A
\$s							

Table 9.
Relative Impacts of Required In-House Pollution Abatement Investment for 1976-1985

Category	Total Investment	Air Abatement Investment	%	Water Abatement Investment	%	Total Air & Water Investment	% Total Investment
Agriculture (Beef Cattle Feedlots)	55,075	0	0	112	0.20	112	0.20
Mining	24,441	135	0.55	0	0	135	0.55
Natural Gas Processing	14,493	53	0.37	0	0	53	0.37
Meat & Poultry	6,887	0	0	546	7.93	546	7.93
Dairy	5,476	0	0	525	9.59	525	9.59
Canned & Frozen Food	11,070	0	0	1,737	15.69	1,737	15.69
Grain Milling & Feed Mills	6,540	948	14.49	53	0.81	1,001	15.31
Beet & Cane Sugar	1,067	0	0	32	2.99	32	2.99
Textiles	29,280	35	0.12	388	1.33	423	1.44
Lumber & Wood Products	8,990	0	0	72	0.80	72	0.80
Furniture	6,543	89	1.36	0	0	89	1.36
Pulp & Paper	48,955	2,473	5.05	5,170	10.56	7,643	15.61
Builder's Paper	5,352	0	0	125	2.34	125	2.34
Printing	13,756	21	0.15	0	0	21	0.15
Chemicals	59,741	591	0.99	5,757	9.64	6,348	10.71
Fertilizers	5,294	97	1.83	242	4.57	339	6.40
Plastics & Synthetics	20,386	41	0.20	1,543	7.56	1,584	7.77
Petroleum & Asphalt	33,782	1,814	5.37	1,644	4.87	3,458	10.24
Paints	2,212	12	0.54	0	0	12	0.54
Rubber Products	11,828	0	0	129	1.09	129	1.09
Leather Tanning	404	0	0	280	69.31	280	69.31
Glass	8,359	0	0	101	1.21	101	1.21
Asbestos, Clay, Lime, & Concrete	18,280	544	2.98	46	0.25	590	3.22
Iron & Steel	55,087	2,584	4.69	2,823	5.12	5,407	9.81
Nonferrous Metals	27,764	1,661	5.98	219	0.79	1,880	6.77
Fabricated Metals & Electroplating	37,053	0	0	8,191	22.11	8,191	22.11
Machinery	95,963	42	0.04	7,369	7.67	7,411	7.72
Transportation Equipment	100,386	98	0.10	3,466	3.45	3,564	3.55
Steam Electric	125,928	7,906	6.28	5,329	4.23	13,235	10.51
Wholesale & Retail (Grain Handling)	226,282	1,204	0.53	0	0	1,204	0.53
Services	198,338	79	0.04	0	0	79	0.04
Cleaning	199,013	80	0.04	0	0	80	0.04
Other Industries	N.A.	3,729	N.A.	0	N.A.	3,729	N.A.
Totals	N.A.	24,156	N.A.	45,899	N.A.	70,055	N.A.s

\$dTable 10.
Ranking of Impacted Sectors by Total Abatement Expenditures
as Percentages of Investment and Output
(1976-1985)

\$t

	Investment				Output							
	Air Rank	%	Water Rank	%	Both Rank	%	Air Rank	%	Water Rank	%	Both Rank	%
Fabricated Metals & Electroplating	-	-	2	22.11	2	22.11	-	-	1	5.30	1	5.30
Pulp & Paper	5	5.05	4	10.56	4	15.61	1	3.21	4	2.05	2	5.26
Leather Tanning	-	-	1	69.31	1	69.31	-	-	2	4.54	3	4.54
Iron & Steel	6	4.69	10	5.12	9	9.81	43	2.61	6	1.55	4	4.16
Steam Electric	2	6.28	13	4.23	7	10.51	2	3.16	9	0.93	5	4.09
Chemicals	10	0.99	5	9.64	6	10.71	9	0.64	3	3.34	6	3.98
Nonferrous Metals	3	5.98	22	0.79	14	6.77	3	2.70	14	0.37	7	3.07
Grain Milling, Feed Mills	1	14.49	20	0.81	5	15.31	6	1.75	21	0.10	8	1.86
Asbestos, Clay, Lime & Concrete	7	2.98	23	0.25	17	3.22	5	1.76	23	0.07	9	1.82
Canned & Frozen Food	-	-	3	15.69	3	15.69	-	-	5	1.78	10	1.78
Petroleum & Asphalt	4	5.37	11	4.87	8	10.24	7	1.28	13	0.39	11	1.67
Plastics & Synthetics	15	0.20	9	7.56	12	7.77	13	0.07	7	1.35	12	1.42
Machinery	20	0.04	8	7.67	13	7.72	18	0.02	8	1.07	13	1.09
Fertilizers	8	1.83	12	4.57	15	6.40	10	0.61	12	0.43	14	1.04
Furniture	9	1.36	-	-	20	1.36	8	0.88	-	-	15	0.88
Dairy	-	-	6	9.59	10	9.59	-	-	10	0.73	16	0.73
Transportation Equipment	18	0.10	14	3.45	16	3.55	16	0.55	11	0.67	17	0.73
Meat & Poultry	-	-	7	7.93	11	7.93	-	-	15	0.29	18	0.29
Beet & Cane Sugar	-	-	15	2.99	18	2.99	-	-	16	0.25	19	0.25
Lumber & Wood Products	-	-	21	0.80	25	0.80	-	-	17	0.24	20	0.24
Paints	12	0.54	-	-	26	0.54	11	0.21	-	-	21	0.21
Glass	-	-	18	1.21	22	1.21	-	-	18	0.19	22	0.19
Natural Gas	14	0.37	-	-	28	0.37	12	0.18	-	-	23	0.18
Builder's Paper	-	-	16	2.34	19	2.34	-	-	19	0.15	24	0.15
Rubber Products	-	-	19	1.09	23	1.09	-	-	20	0.13	25	0.13
Textiles	17	0.12	17	1.33	20	1.44	19	0.02	22	0.10	26	0.12
Wholesale & Retail (Grain Handling)	13	0.53	-	-	27	0.53	14	0.06	-	-	27	0.07
Mining	11	0.55	-	-	24	0.55	15	0.06	-	-	28	0.06
Printing	16	0.15	-	-	30	0.15	17	0.04	-	-	29	0.04
Agriculture	-	-	24	0.20	29	0.20	-	-	24	0.02	30	0.02
Services (Dry Cleaning)	19	0.04	-	-	31	0.04	20	0.01	-	-	31	0.01
												\$\$\$\$

\$aChapter 5
Estimating Pollution Control Costs

\$bCOMPARISON OF INVESTMENT ESTIMATES
FOR AIR POLLUTION WITH ESTIMATES OF BEASR

The year-by-year estimates of air pollution investment necessary to equip over half of the existing plants with required control devices by the beginning of 1976 and all such plants to be fully controlled by the end of 1978 appear to be optimistic when compared with the Bureau of Economic Analysis estimates of actual air pollution investment expenditures in 1973 and 1974, and planned expenditures for 1975. Table 1 shows BEA estimates common to both studies as a percentage of the estimated necessary expenditures for the three years.

Note that collectively, industries were spending about the right amount in 1973 to meet the above schedule. Ferrous Metals and Food, however, were well behind schedule even at this point. By 1974, the total for all industries had slipped behind the pace. Possibly as an aftermath of the economic recession, attempts to fight EPA in the courts, or whatever, industries as a whole had dropped to less than 70 percent of the expenditure level needed to meet the above

schedule. Ferrous Metals and Food dropped even further behind than was shown for 1973.

Table 1.
Comparison of Estimated Requirements and BEA
Estimates of Actual Air Pollution Investment
Expenditures for 1973, 1974, and 1975
(BEA estimates as a percent of EPA estimates)

\$t	1973	1974	1975	1973-1975
All Industries	105%	69%	38%	57%
Electric Utilities	182%	139%	123%	141%
Ferrous Metals	24%	16%	19%	19%
Nonferrous Metals	129%	49%	46%	63%
Stone, Clay, Glass	43%	47%	32%	39%
Food	32%	17%	17%	20%
Paper	45%	49%	60%	52%
Chemicals	155%	105%	106%	118%
Petroleum	184%	142%	369%	144%\$R

By 1975, the expenditures planned by industries were only slightly above a third of that needed to meet the expenditure schedule of the Reference Abatement Scenario. However, three industries (Steam Electric, Chemicals, and Petroleum) are planning to install more equipment than the schedule demands. For example, Petroleum is planning to spend at a level three and a half times greater than estimates indicated would be needed by 1975. Additionally, a fourth sector, Paper, does not achieve the required pace during these years, but it improves its percentage with each year.

ESTIMATING OTHER SIGNIFICANT
ENVIRONMENTAL CONTROL COSTS

All of the industrial control costs (except for Steam Electric) are endogenously determined. That is, the industrial costs are calculated using existing plants and estimated numbers of new plants that are to be built in response to overall economic activity forecast by the SEAS economic projections. Therefore, if one scenario has a 10 percent higher GNP than another by 1985, it will consequently normally forecast more new plants and higher pollution abatement costs. This factor explains a great deal of the differences between the Reference Abatement Scenario costs and previous estimates by EPA and other agencies.

Three additional types of environmental control costs are important. These are the costs associated with mobile sources, municipal treatment, and governmental expenditures. These costs are determined outside the dynamics of the national economic forecasting models, but are made consistent with the results of these models. For example, the control costs associated with new automobiles are very dependent upon the forecast of new car sales. When national conditions change in such a way as to alter the baseline

projection of new car sales to 1985, the inputs to the mobile source control calculations are correspondingly adjusted.

\$Estimating Air Costs for Mobile Sources\$R

Mobile source air pollution control costs are generated as a result of emission standards for light duty vehicles (LDV), heavy duty vehicles (HDV), and aircraft, plus the impact of State Transportation Control Plans (TCP's). The Clean Air Act specifies mobile source emission levels for hydrocarbons, carbon monoxide, nitrogen oxides. The costs for mobile sources are based upon the existing regulations as of August 1975.

The costs to reach the standard emission levels by the target years is estimated by a model that ages the present stock of vehicles, year by year, taking into account new vehicle sales that are based upon the GNP and personal income figures provided in the scenarios discussed in the macroeconomic analyses.

These calculated mobile source control costs are then fed back through the InterIndustry model. As an example, the capital expenditures for automobile control devices are

treated as additional expenditures for Motor Vehicles and Parts. The O&M expenditures are fed back through Auto Repair.

The total costs for all controlled mobile sources during the 1971-85 period is estimated to be \$140 billion. This is by far the largest single source of air pollution abatement costs.

Concentrations of carbon monoxide and smog (caused by hydrocarbons and nitrogen oxides reacting in sunlight) are so high in 27 metropolitan areas that even the stringent stationary source controls and the Federal emission standards do not reduce emissions sufficiently to meet Federal ambient standards. These areas have developed Transportation Control Plans (TCP's) that involve combinations of additional mobile source controls (more retrofit devices for existing vehicles, plus strong inspection and maintenance measures) and vapor control systems for gas stations.

The TCP costs are estimated to be \$3.8 billion over the 1976-85 period, and approximately 90 percent of this cost is for inspection and maintenance of automobiles to insure that their pollution control devices are operating at the proper effectiveness. These are expenditures made primarily by

automobile owners. However, increased engine performance maintenance results in significant fuel economy, which is a direct economic benefit to automobile owners. Offsetting the increased maintenance costs with the fuel savings actually produces a small net benefit. (Refer to Section Three, Transportation Control Plans, for further detail.)

\$bEstimating the Water Costs for Municipal Treatment\$R

Municipal water pollution control expenditures comprise the largest single category of water pollution control expenditures. Municipal expenditures are divided into six types:

- Secondary treatment
- Treatment more stringent than secondary (removal of phosphorus, ammonia, nitrates, and organic pollutants)
- Rehabilitation of sewers
- New sewers
- Correction of overflow from combined sewers

- Stormwater treatment

Federal funds spent for municipal treatment are based upon past expenditures and the present funding authority of \$18 billion for construction. State-local matching expenditures are expected to be a third of the Federal construction grant (i.e. Federal funds comprise about 75 percent of construction expenditures). Capital expenditures are estimated to be \$67 billion over the 1971-85 period, and O&M expenditures (made by state-local governments) are estimated to be \$20 billion over the same period.

\$Estimating Air and Water

Abatement Costs to Government\$R

Estimates of governmental expenditures for air pollution were made by using Office of Management and Budget (OMB) estimates of Federal expenditures and calculating state and local expenditures by building upon data for 15 sample states for which estimates of the costs of the State Implementation Plans were available.

The governmental water control costs exclude the Federal and state-local expenditures for municipal treatment (covered

elsewhere under the Municipal Expenditures title), but they do include expenditures for:

- Monitoring
- Technical assistance
- Grant assistance
- Research
- Abatement at government-owned facilities.

The total governmental expenditure is estimated to be over \$12 billion during the next decade. This expenditure on an annual basis is never even as large as one percent of the total estimated annual non-defense governmental expenditure during the 1976-85 period.

\$BESTIMATING OTHER IMPACTS\$R

Previous estimates of the cost of air and water pollution control by EPA have been presented in separate reports. The Cost of Clean Air and The Economics of Clean Water. In these reports, costs were computed on an industry-by-industry basis and then summed to arrive at a total pollution control cost for air and water, respectively. The two reports, however, often differed in such assumptions as the growth in industrial capacity to be controlled and the rate of interest. In addition, no estimates were developed in either report on the combined impact of air and water pollution control expenditures on the economy in terms of increased construction, equipment purchases, operating materials, energy demand, and employment.

For this report, a consistent set of assumptions were developed and entered into SEAS for the computation of both air and water pollution control costs. Impacts were then estimated through the feedback of abatement purchases within SEAS. These include direct impacts on the demand for abatement equipment and materials from supplying industries, as well as on abatement-related employment for operating and maintenance activities in using industries. Additional feedbacks were used to estimate the indirect effects of

abatement costs on the capital required to finance
abatement-related construction and major equipment purchases
and on the energy consumed by abatement activities. The
estimated direct and indirect impacts resulting from these
feedbacks are presented below.

\$bCapital and O&M Impacts\$R

Each air pollution device and each water control technology that has a capital and/or O&M cost associated with it, can be treated as a purchase of goods and services from other sectors of the economy. For example, the three principal air pollution control devices for industrial sources - electrostatic precipitators (ESP), scrubbers, and fabric filters (baghouses) - have the capital and operating feedback expenditure pattern shown in Table 2. The table shows that for every \$100 in capital expenditure for precipitators, \$48.90 goes to the New Construction sector, \$8.00 goes to the Cement, Concrete, Gypsum sector, etc. Similarly, for every \$100 in non-labor O&M spent on precipitators, \$56.70 goes for maintenance, \$42.80 goes for electricity and \$.50 goes for paint materials.

When the full set of feedback matrices are examined, one can get an a priori indication of which industries will be impacted positively (via increased sales) as a result of the pollution control expenditures. From Table 2, it appears that new and maintenance construction, as well as electricity purchases, will be increased significantly as a result of investment and O&M expenditures for air pollution control.

To examine the feedback impacts on the key sectors listed in the previous table, the output for several years is compared for the case with abatement and without abatement. As Table 3 shows, the capital feedbacks affect industries prior to 1985, whereas the O&M feedbacks are strongest in 1980 and 1985 when most plants are in compliance with air and water regulations.

Table 3.
Percent Increase in Output with Addition of
Abatement to the Reference Case

Sectors	\$t 1975	1980	1985
New Construction	14.8	6.0	1.3
Maintenance Construction	3.1	3.1	3.0
Cement, Concrete, Gypsum	12.8	3.3	0.8
Plumbing & Heating Equip	11.1	0.3	0.8
Structural Metal Products	8.1	2.8	1.0
Other Fabricated Metal	22.0	2.7	1.0
Pumps, Compressors, Blowers	7.0	0.6	-0.2
Industrial Controls	21.3	0.9	0.5
Electric Utilities	3.3	3.8	3.3
Water and Sewer Services	2.3	3.7	3.1

These estimates should not be viewed as projections of what will happen, but what would have to happen if the assumptions about the timing of pollution control expenditures are accepted. Specific sectors of the economic system may not actually be able to absorb the amount and timing of pollution investment as this analysis shows would be necessary.

\$bEmployment Impacts\$R

By the year 1985, the level of employment within the pollution control activities of the nation's industries and municipal waste treatment facilities is estimated at 467,000 employees. The breakdown by major employment category is as follows:

Thousands of Workers

Total Direct Employment (1985)	466.5
Air Pollution Control	20.2
Water Pollution Control	446.3
Municipal	59.2
Industrial	387.1
Machinery, Equipment, &	219.3
Fabricated Metals	
Organic Chemicals	29.9
Other	137.9

To provide an insight to the buildup of the direct employment being used in operation and maintenance of pollution equipment, the levels for the projected years are listed below:

	Thousands of Workers			
Total Direct Employment	1977	1980	1983	1985
Industrial Air Pollution Control	16.7	21.4	21.2	20.2
Industrial Water Pollution Control	153.3	218.8	252.1	387.1
Municipal Water Pollution Control	27.6	52.1	57.2	59.2
TOTALS	197.6	292.3	330.5	466.5

The levels of direct employment are calculated based on the specific industry and the associated pollution control technologies that are operating in that year. For each technology, the amount of each O&M dollar spent includes the fraction spent for direct labor and the mean annual salary required to determine these direct employment levels

Other effects on employment levels exist due to pollution control actions; these include employment generated by purchases of pollution control construction, equipment and materials, plus general impacts of the change in the final demand and industry demand mix on the GNP and the total industrial product and services outputs. Earlier, it was noted that the introduction of pollution control equipment on the Reference Case caused outputs of some sectors (e.g., miscellaneous machinery) to increase while dampening the outputs of others.

The employment at the national level in 1985 is about 260,000 persons greater for abatement than without abatement, but since 467,000 of the total with abatement are employed in controlling pollution, this means that there are about 206,000 fewer workers in 1985 producing output that contributes to GNP as presently defined. The 467,000 workers who are working toward "producing a cleaner environment" are not counted as "producing goods and services" as conventionally defined in national economic accounts.

Table 4 below provides a listing of the change in employment between the Reference Scenario and the Reference Abatement Scenario.

Table 4.
Employment Changes Resulting from Pollution Controls
(Thousands)

\$t Year	Total Employment S1	S2	Difference S2 S1	Total Direct pollution Cntrl Employment
1977	90,266.4	92,072.1	1805.7	197.6
1980	96,752.0	97,143.8	391.8	292.3
1983	100,893.5	101,205.7	312.2	330.5
1985	103,113.2	103,373.9	260.7	466.5

The table can be interpreted as follows: The difference between S2 and S1 reflects the increase in total employment

due to the impact of pollution control on the general economy. A comparison of these figures with those shown in the last column indicates that the employment gains directly associated with pollution control dominate the more indirect employment effects in the later years.

\$bEnergy Impact\$R

The direct and indirect energy costs of the air and water abatement schedule can be determined by comparing the national Btu consumption in 1985 in the Reference Abatement Scenario (when controls are in place) with the Btu consumption in the Reference Scenario (with the same 1985 GNP but no incremental abatement past 1971). This comparison, presented by consumer class in Table 5, reveals that total Btu consumption increased by 3.6 percent with abatement. Most of this increase comes in the use of energy by electric utilities, which increased a net of 5.2 percent.

Industrial Chemicals accounted for the largest portion of the net energy increase of 3.3 percent by industries. Other large increases in energy use were registered by Steel, Aluminum, and Petroleum. Several industries increased their electricity consumption dramatically when pollution abatement was adopted by all industries. For example,

Phosphate Fertilizer increased its consumption by 66 percent. Aluminum by 30 percent, and Steel by 19 percent

Table 5
Increase in Energy Consumption with Addition
of Abatement to the Reference Case

Consumer Class	1985 Energy Use (Trillions of Btu's) \$1	\$t \$2	Percent Change (S2-S1)/S1 x 100
Industrial	26,058.8	26,909.9	3.27
Transportation	24,635.8	25,212.0	2.34
Commercial	7,425.1	7,413.5	-0.16
Residential	9,779.5	10,108.3	3.36
Electric Utilities	41,110.2	43,250.4	5.21
TOTALS	109,009.3	112,894.2	3.56

Ranking of Sectors by Degree of Change

Additional detail in changes in industry data from the Reference Scenario to the Reference Abatement Scenario is given in Table 6 for the forecast years 1977, 1980, 1983, and 1985.

In Table 6(A); the 10 industries with the greatest percentage of increases in output from the Reference Scenario to the Reference Abatement Scenario are given. The

Impact of capital investment and O&M purchases for the four years can be noted in the rankings and the percentage change. For example, the timing requirements for installation of pollution control equipment are evidenced by the industry of New Construction being stimulated about 13.4 percent in 1977, decreasing to 6.0 percent in 1980, dropping to 3.1 percent in 1983, and then down to 1.3 in 1985. A major O&M purchase is from Industrial Chemicals. This sector is ranked eighth in 1977 (10.2 percent), third in 1980 (9.5 percent), and rises to second in 1983 (9.1 percent) and first in 1985 (10.2 percent). The extraction of energy ores and sales of energy show trends similar to Industrial Chemicals. The peaking and dropoff of equipment fabrication sectors is consistent with the construction pattern (for example, note the values and ranks for Pipes, Valves and Fittings, Special Industrial Machinery, and Electric Lighting and Wiring Equipment).

The converse of these impacts are provided in Table 6(B): the six industries suffering the greatest percentage decrease in outputs for each year. The general categories that are impacted are mass transit and minor transportation equipment, and personal clothing items. The level of impact here is much less than the level of impact to the growing industries. During the late 1970's, the greatest negative impact is only one-third of the tenth greatest positive

impact. For 1983, the level of negative impacts for the six industries is about double those of 1977 and 1980; yet even then the largest negatively-impacted industry is on the order of the tenth largest positively-impacted industry.

Table 6(C) provides a ranking of the construction industries that are most stimulated for the four years. The sector of Water Systems Construction continues throughout the period as high-ranked with the associated sector of Sewer Systems Construction being high through 1980. The increase demand for energy is reflected in the increasing demand for Gas Utility and Pipeline Construction and Electric Utility Construction through 1985. The early combined demand for air pollution and water BPT pollution controls caused Industrial Construction to be ranked third in 1977.

Turning to the positive stimulus on industries for capital equipment investment, Table 6(D), the highest-ranked industries for each year are usually industries that would provide equipment or maintenance products for pollution control. For each of the four years, three industries appear in the top five: Motor Vehicles and Parts, Hardware & Platings, and Miscellaneous Machinery and Shops.

Tables 6(E) and 6(F) provide the major impacted industry sectors in terms of percentage change of personal

consumption expenditures (PCE). Table 6(E) lists all sectors having an increase change of greater than 1 percent for the four years. For the years 1980, 1983, and 1985, only four sectors achieve this level.

Table 6(F) includes the five greatest negatively-impacted sectors, given that the sector has a PCE volume of over 100 million dollars. Three sectors occur in all four years, Buses and Local Transit Services, Pottery Products, and Cycles and Minor Transportation Equipment. Other products represented in the set are other transportation services and, in the 1980's, clothing products. Thus, the negatively-impacted sectors for the measures of total output and for PCE are generally consistent.

\$dTable 6.
Sectors Ranked by Greatest Percent Change
Between Reference Scenario and Reference Abatement Scenario

A. Greatest Percentage Increase in Output		\$t					
		1977	1980	1983	1985		
Special Industrial Machinery	15.8	Pipes, Valves, Fittings	16.8	Pipes, Valves, Fittings	10.8	Industrial Chemicals	10.2
Structural Clay Products	13.9	Special Industrial Machinery	12.1	Industrial Chemicals	9.1	Natural Gas	7.4
Pipes, Valves, Fittings	13.4	Industrial Chemicals	9.5	Special Industrial Machinery	6.5	Chemical Fert. Mining	6.3
New Construction	13.4	Crude Petroleum Natural Gas	6.5	Crude Petroleum Natural Gas	6.1	Crude Petroleum Natural Gas	6.3
Other Fabricated Metal Products	13.4	New Construction	6.0	Natural Gas	5.9	Pipelines	4.7
Industrial Controls	12.6	Auto Repair	6.0	Chemical Fert. Mining	5.5	Complete Guided Missiles	4.4
Cement, Concrete, Gypsum	12.4	Chemical Fert. Mining	5.6	Pipelines	4.6	Lead	4.4
Industrial Chemicals	10.2	Elec. Lighting & Wiring	5.5	Complete Guided Missiles	4.6	Misc. Chemical Products	4.0
Auto Repair	9.9	Natural Gas	5.1	Misc. Chemical Products	4.1	Coal Mining	3.3
Elec. Lighting & Wiring	9.7	Pipelines	5.1	Auto Repair	4.1	Electric Util.	3.3
B. Greatest Percentage Decrease in Output:							
Cycles, Minor Trans. Equipment	-0.8	Railroad Equipment	-2.9	Construction, Mining Oil Field Mach.	-4.3	Buses & Local Transit	-3.6
Apparel	-0.8	Buses & Local Transit	-2.5	Machine Tools, Metal Forming	-3.7	Construction Mining, Oil Field Mach.	-3.5
Buses & Local Transit	-0.7	Cycles, Minor Trans. Equipment	-2.4	Buses & Local Transit	-3.5	Machine Tools, Metal Form.	-2.2

Table 6.
Sectors Ranked by Greatest Percent Change
Between Reference Scenario and Reference Abatement Scenario

\$t							
B. Greatest Percentage Decrease in Output							
Knitting	-0.4	Construction, Mining, Oil Field Mach.	-2.3	Railroad Equipment	-2.6	Apparel	-2.0
Footware	-0.3	Apparel	-2.3	Machine Tools, Metal Cutting	-2.4	Cycles, Minor Trans. Equip.	-1.6
Leather & Ind. Leather Prod.	-0.3	Jewelry & Silverware	-2.1	Cycles, Minor Trans. Equipment	-1.8	Footware	-1.5

C. Greatest Percentage Increases in Construction Sectors

1977	1980	1983	1985
Sewer Systems	170.1	Water Systems	Water Systems
Water Systems	108.0	Sewer Systems	Gas Utilities & Pipelines
Gas Utilities & Pipelines	9.5	Gas Utilities & Pipelines	Electric Utilities
Industrial	3.9	Electric Utilities	Water Systems
Electric Utilities	2.9	Water Systems	Gas Utilities & Pipelines
Telephone	1.5	Gas Utilities & Pipelines	Electric Utilities
Stores, Restaurants, & Garages	1.3	Electric Utilities	Water Systems

\$Table 6.
Sectors Ranked by Greatest Percent Change
Between Reference Scenario and Reference Abatement Scenario

\$t							
D. Greatest Percentage Increase in Capital Investment							
Hardware, Plating	167.2	Misc. Machinery & Shops	1653.9	Misc. Machinery & Shops	950.1	Motor Veh. & Parts	61.9
Motor Veh. & Parts	134.6	Motor Veh. & Parts	168.6	Motor Veh. & Parts	106.1	Misc. Machinery & Shops	47.6
Eng. & Scientific Instruments	76.2	Hardware, Plating	120.2	Eng. & Scientific Instruments	84.6	Hardware, Plating	32.2
Misc. Machinery&Shops	72.7	Eng.&Scien. Instr.	106.3	Hardware, Plating	80.4	Industrial Chem.	14.8
Industrial Chem.	67.4	Canned & Frozen Foods	15.2	Industrial Chem.	9.3	Canned & Frozen Foods	13.6
E. Greatest Percentage Increase in PCE (all sectors that > 1.0%)							
Trucking Services	33.7	Trucking Services	46.6	Trucking Services	56.3	Trucking Services	61.8
Auto Repair	15.0	Auto Repair	9.7	Auto Repair	6.7	Nat. Gas Sales	5.3
Petroleum Refining	7.7	Petroleum Refining	6.1	Natural Gas Sales	5.0	Auto Repair	5.0
Natural Gas Sales	3.8	Natural Gas Sales	4.4	Petroleum Refining	4.4	Petroleum Refining	3.7
F. Greatest Percentage Decrease in PCE (PCE for sector > 100M\$)							
Railroad Trans.	-2.8	Buses & Local Trans.	-5.0	Buses & Local Trans.	-5.9	Buses & Local Trans.	-6.0
Buses & Local Trans.	-2.7	Non-Competitive Imports	-3.6	Cycles, Minor Trans. Equipment	-2.6	Cycles, Minor Trans. Equipment	-2.5
Pottery Products	-1.8	Pottery Products	-3.4	Pottery Products	-2.4	Pottery Products	-2.4
Cycles, Minor Trans. Equipment	-1.8	Railroads	-2.9	Footware	-2.0	Apparel	-2.1
Glass	-1.0	Cycles, Minor Trans. Equipment	-2.6	Apparel	-1.9	Footware	-2.0
\$s							

5bTHE DYNAMIC NATURE OF TOTAL
POLLUTION CONTROL EXPENDITURES\$R

Earlier in this analysis, the costs to control air and water pollution were stated in terms of dollars expended over some relatively short time period. The amount and timing of expenditures during the next 10 years is important, but the impression should not be left that total expenditures decline radically after the first round of investments in pollution equipment.

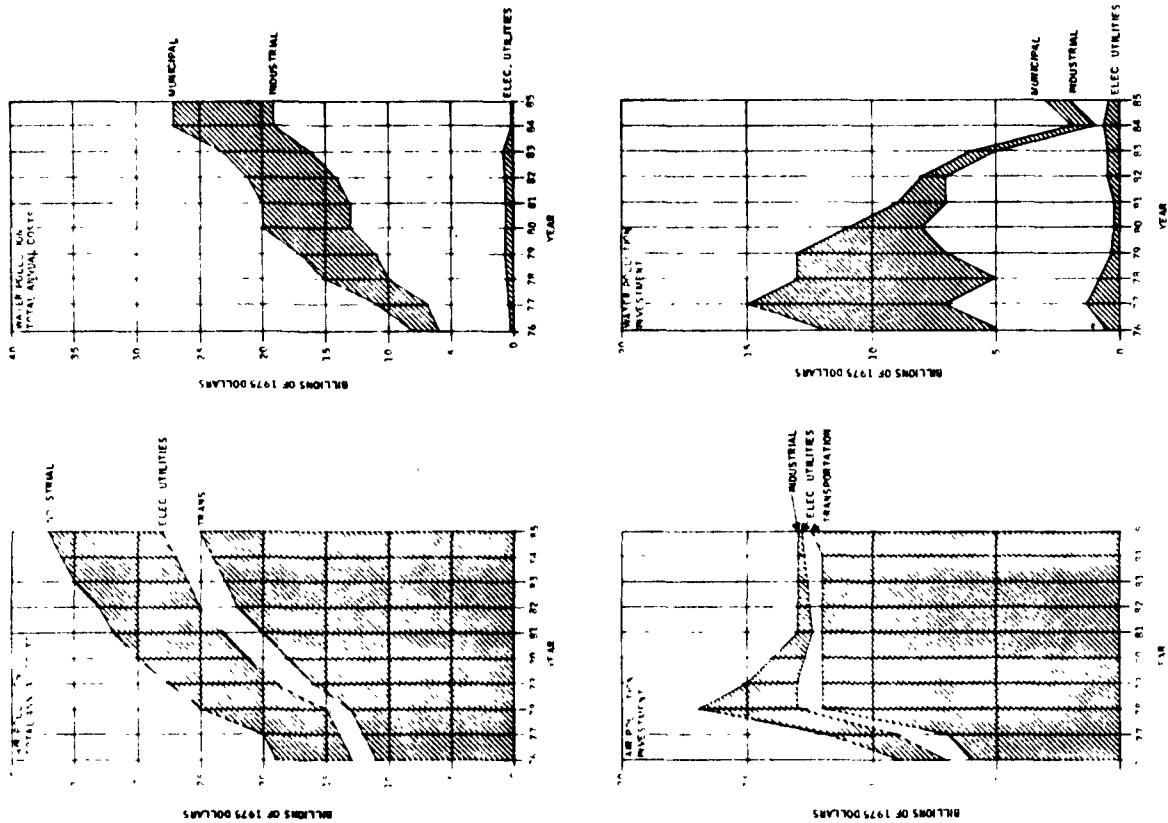
Figure 1 shows investment and total annual costs (annualized capital plus O&M) for air and water pollution control. Although the year-by-year expenditures are admittedly assumptions, the general trends of the lines are reasonable estimates of expenditures (given the overall assumptions of the Reference Abatement Scenario).

Note that in the case of air investment expenditures, Electric Utilities and other industrial sources do demonstrate a peaking of expenditures during the 1973-78 period with very small annual investment expenditures by 1985. The total annual costs, likewise, grow and then level off after 1980.

No such leveling off is witnessed for water pollution total annual costs, but this might occur just a few years beyond 1985 since investment expenditures have begun to decline by 1984, and the effluent regulations after 1983 may require lower increases in pollution costs after 1985.

3800
3801
3802

Figure 1.
Annual Investments and Total Annual Costs for
Air and Water Pollution Control, 1976-1985



By the year 1985, O&M expenses for industries are approximately \$16.9 billion for air and water pollution control combined (see Table 7). Water expenses make up the largest part of this total, 61 percent. The industrial sectors making the largest O&M water expenses in 1985 are:

	Billion 1975\$	Percent of Total Industrial Water O&M
Machinery and Equipment	6.35	57.3
Chemicals	1.82	16.4
Food Processing	7.6	6.9
Ferrous Metals	7.4	6.7
Paper	6.3	5.7

Table 7.
Industrial Sector Annual Expenditures
(Billions 1975 Dollars)

\$t	Air		water		Total
Year	Annual Capital	O&M	Annual Capital	O&M	Annual Capital O&M
1972	0.5	0.4	-	-	0.5 0.4
1973	1.3	1.0	-	-	1.3 1.0
1974	2.5	1.8	0.7	1.2	3.2 3.0
1975	3.6	2.8	1.6	2.7	5.2 5.5
1976	4.0	3.5	2.2	3.7	6.2 7.2
1977	4.8	4.1	3.1	4.9	7.9 9.0
1978	5.6	4.6	3.7	5.9	9.2 10.5
1979	6.1	5.0	4.5	6.4	10.6 11.4
1980	6.3	5.3	5.5	6.8	11.8 12.1
1981	6.5	5.4	6.4	7.2	12.9 12.6
1982	6.6	5.4	7.3	7.5	13.9 12.9
1983	6.7	5.4	8.0	7.8	14.7 13.1
1984	6.8	5.4	8.2	11.0	15.0 16.3
1985	6.9	5.4	8.4	11.5	15.3 16.8

Parts may not sum to total because of rounding.\$R

A great part of the O&M expenditures for water pollution control go for labor expenses. This is not true for air pollution control, however, as shown in Table 8:

Table 8.
1985 O&M Expenditures and Direct Labor
Requirements for Industries

\$t	O&M (Billions 1975\$)	Direct Labor (1,000's)	Employees/ Million \$
Water Pollution Control	11.4	385	33.8
Air Pollution Control	5.4	20	3.7\$R

Based on these figures, the average O&M expenditures in 1985 are stimulating direct O&M employment of

34,000 jobs per billion dollars of water pollution control O&M, and 3,700 jobs per billion dollars of
air O&M expenditures

Appendix A

The SEAS System

A Brief Description

SEAS is a system of interdependent models and computer programs developed by EPA to assess the future economic and environmental consequences of Federal pollution control policies. Structurally, the system consists of a number of special-purpose models linked to the University of Maryland's INFORUM, interindustry input-output model of the economy. The INFORUM model develops economic forecasts through 1985 based on alternative sets of demographic and macroeconomic assumptions specified by the user. In turn, these forecasts form the basic economic inputs used by other models in SEAS to develop their more specialized forecasts.

A generalized overview of the SEAS system is presented in Figure A-1. As indicated by the dashed-lined box, two special-purpose SEAS models have been integrated into a common program with INFORUM, INSIDE, which provides greater detail on industrial output, and ABATE, which contains cost functions for abatement technologies. Together, these three models form the national economic forecasting program for the SEAS system. This program is fed by two data bases: one contains economic and pollution abatement costs data; the

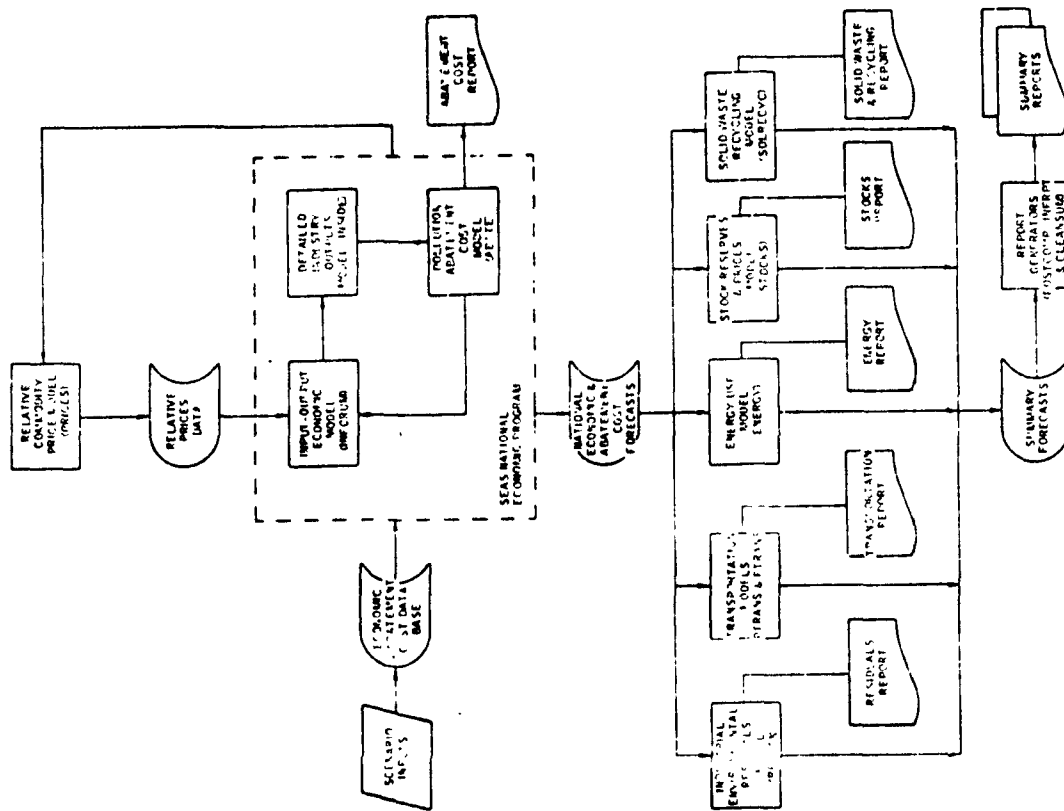
other, data on relative commodity prices. A feedback loop between the national economic program and the PRICES model allows for price effect adjustments to be reflected in the SEAS economic forecasts. The final output file, containing annual economic and abatement cost forecasts through 1985, provides input data for six other special-purpose models:

- RESGEN - Estimates the annual tonnage of pollutant residuals from industrial sources.
- PTRANS - Estimates the passenger transportation variables and residuals.
- FTRANS - Estimates the freight transportation variables and residuals.
- ENERGY - Develops forecasts of energy consumption.
- STOCKS - Provides information on the price and availability of critical virgin stocks.
- SOLRECYC - Estimates the annual tonnage of solid waste and recycled materials.

Summary output from these models, as well as the national economic program, is then collected in a common file for the production of summary reports.

3434
3435
3437
3438

Figure A-1.
Generalized Flowchart for the Strategic
Environmental Assessment System (SEAS)
(As Applied for this Report)



A description of the major functions performed by each of the SEAS models is presented below. This discussion of SEAS emphasizes the computation of abatement costs and their associated economic feedbacks as a subsystem of the overall model structure.

THE INTERINDUSTRY ECONOMIC FORECASTING MODEL (INFORUM)

The INFORUM model projects future economic activity using structural relationships between economic and demographic variables. These projections determine total demands for the outputs of 185 industrial sectors, and then allocates these demands to the specific markets, or buying sectors, to which these products are sold. Thus, the model differentiates between intermediate demands and final demands. Intermediate demands are generated by sales from one industry to other producing industries. Final demands are developed from government expenditures, exports, imports (expressed as negative exports), purchases by consumers, changes in inventories, and savings and investment. These final demand components make up what is commonly referred to as Gross National Product (GNP).

Figure A-2 displays a flow diagram of the INFORUM model.

The solid lines track the basic model. The column of boxes on the far left of the diagram denote factors which are specified outside the model. The solution procedure is as follows.

A trial value of disposable income is coupled with relative prices such that personal consumption expenditures may be calculated. These results, combined with the projections for households and interest rates, are used to determine expenditures for various construction types. Sales to construction investment by each industry is determined by applying the C-matrix coefficients. In a similar manner, the sales by each industry to the government categories are determined by feeding the G matrix with assumptions concerning government policy and defense planning. Outputs of previous years and assumptions regarding the costs of capital are used to forecast investment in producer durable equipment and industry-related construction. Investment by industry is then determined by running these forecasts through the C- and B-matrices. At this point, total final demands have been determined.

The A-matrix of coefficients then serves to convert final demands to total product outputs by industry. Net imports and inventory changes are computed simultaneously. Labor

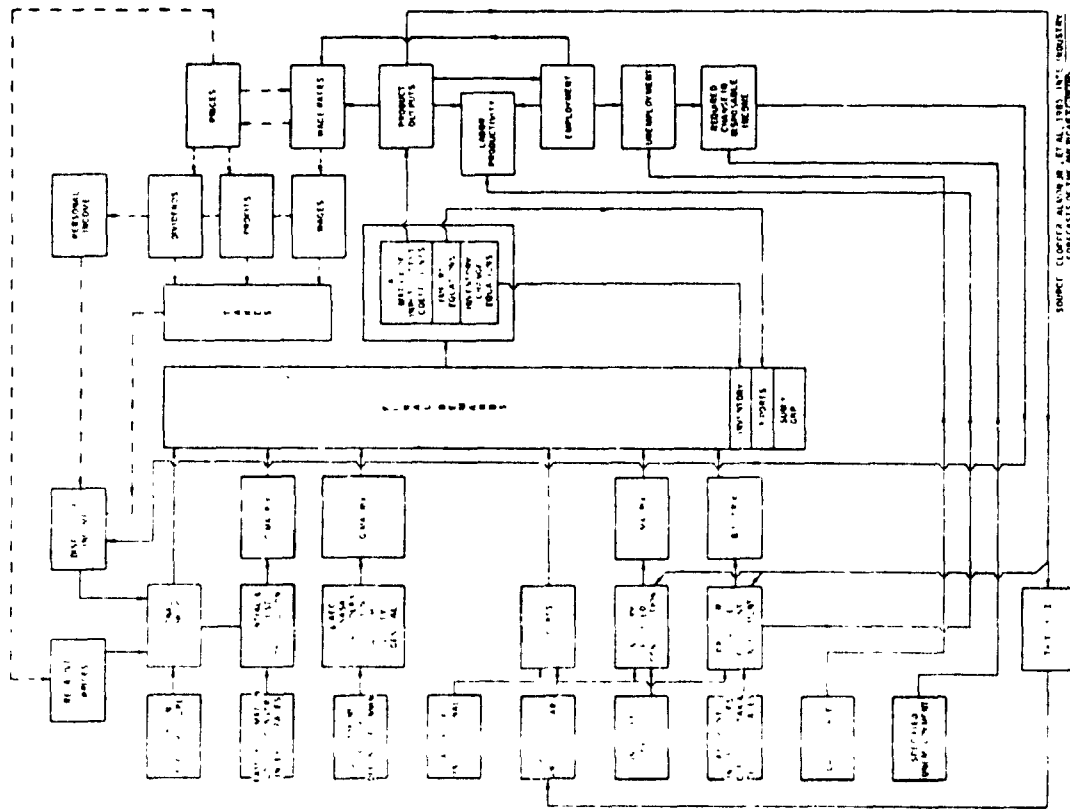
productivity is derived from changes in output and capital investment. Employment is determined by dividing the product outputs by labor productivity. If this result, when subtracted from labor force projections, yields a level of unemployment out of line with previously specified levels, the disposable income assumption is modified and calculations begin anew. Otherwise, the outputs so generated by the model, coupled with the projections of outside factors, are applied to forecast the next year's economic activity.

For most scenarios run for this report, official government forecasts of productivity and unemployment were used in place of those estimated by the INFORUM model as supplied by the University of Maryland. The higher productivity forecasts of the Bureau of Labor were entered into INFORUM exogenously. Personal disposable income was then adjusted as necessary in each scenario to bring unemployment in line with government forecasts. For these scenarios, INFORUM was thus used to compute the redistribution of intermediate sales among industrial sectors required to meet the government projections.

The SEAS PRICES model, also adopted from the University of Maryland, provides INFORUM with relative indexes of prices among commodities. Two runs of INFORUM for each scenario

are required to make use of the PRICES model. The first run of INFORUM produces a different distribution of sales than that assumed in creating the original set of price indexes. The PRICES model is then run to generate a modified set of indexes to be used by INFORUM. The INFORUM model is then rerun to provide a new forecast of the economy which takes into account the price changes resulting from the redistribution of sales.

Figure A-2.
Flow Diagram of the Inform Model with Evolution Procedure



SOURCE: CLIFFORD ALANSON, ET AL., 1985, "AN INDUSTRIAL
ECONOMICS OF THE AMERICAN SOUTH"

\$BTHE SECTOR DISAGGREGATION

MODEL (INSIDE)\$R

The INSIDE model performs two important functions (1)Ait projects subindustry outputs at the level of detail required for environmental assessment; and (2)Ait forecasts changes in industrial growth due to technological substitution. INFORUM is an economic forecasting model which was not specifically designed to deal with environmental issues. Hence, the different production processes included within any single INFORUM sector may generate significantly different pollution or demand trends. Similarly, alternative processes may be available within a sector for producing the same material or product.

Special equations, termed side equations, are introduced by the INSIDE model to enable SEAS to account for environmentally-important product and process technology details not available directly from INFORUM. These equations disaggregate the annual sector outputs in dollars from INFORUM into annual outputs in physical units at a more detailed subsector level. For example, there are several hundred major chemicals embedded within INFORUM Sector 55, which projects the economic activity for all industrial chemicals. However, the manufacture of nitric acid

generates the vast majority of nitrogen oxide emissions produced by this industry. About 80 percent of the nitric acid manufactured is sold to fertilizers and miscellaneous chemicals, whereas Sector 55 sells over 50 percent of its output to plastics, non-cellulose fibers, cleaning and toilet preparations, miscellaneous chemicals, and paints. As a result the growth rate of nitric acid alone does not parallel the aggregate growth of all industrial chemicals in Sector 55. Thus, relating nitrogen oxide generation to nitric acid demand in other sectors rather than to the aggregate of Sector 55 gives a more accurate projection of nitrogen oxide emissions and control costs.

Technological substitutions in SEAS can occur among two to four alternative materials, processes, or products within a given industry. Examples of two-, three-, and four-way substitutions are presented below:

Table A-1.
Example of Technological Substitutions in SEAS

St Type of Substitution	Commodity	Alternative Processes
2-Way	Chlorine	(1) Chlorine Cell (2) Diaphragm Cell
3-Way	Steel	(1) Electric Arc (2) Basic Oxygen (3) Open Hearth
4-Way	Non-Nuclear Electric Utilities	(1) Coal (2) Oil (3) Gas (4) Others\$R

The user specifies the substitution ratio as the fraction of a commodity produced by each alternative process. The rate of substitution is also determined through user inputs. Thus, the INSIDE side equations can reflect the growth of the diaphragm cell manufacturing process for chlorine at the expense of the market share for the mercury cell process.

\$BTHE ABATEMENT COST AND FEEDBACK

MODEL (ABATE)\$R

The ABATE model estimates the investment costs and the operating and maintenance (O&M) costs associated with the control of air and water pollution for all significant polluting industries. It also provides feedback on the consequent increases in capital investments, employment requirements, consumption levels, and economic demands to INFORUM. The INFORUM model then uses this data to dynamically rebalance its forecasts of economic activity and produce revised estimates of such macrostatistics as GNP and unemployment, as well as relative shifts in interindustry demands and outputs.

The input data required by the ABATE model was compiled through research into the technological control options and associated costs for meeting environmental standards. In general, the data used in the model corresponds directly to the industry-by-industry descriptions of abatement activity given in Sections Two and Three of this report. Some of the more important data inputs are discussed below:

1. All Categories Except Municipal Wastewater Treatment.

The following data was developed for input to the ABATE

model for all cost categories other than for municipal wastewater treatment:

a. An inventory of plants, including size distribution of the total capacity of the industry category for a base year, was developed using the best information available from one or more of the following sources:

- Researcher files
- Trade associations
- Professional societies
- Directories of plants
- Periodic publications
- Government research documents.

b. Capital cost functions and O&M cost functions were specified for each standard (State Implementation Plans, Best Practicable Technology, Best Available Technology, and/or New Source Performance Standards). These functions relate cost to the physical measure of plant capacity used for the plant inventory. For industry categories involved in water pollution abatement, cost functions were developed for both the full in-plant treatment and pretreatment options.

c. For each industry category, capital and O&M costs were allocated as purchases from INFORUM sectors on the basis of the technology option(s) associated with the category.

d. The average life of the abatement equipment and a nominal interest rate of 10 percent were specified for each industrial category to enable the model to calculate annualized capital costs.

e. Compliance years for each standard which applies to the industrial category and also the year after which all new plant construction starts must meet New Source Performance Standards were specified.

f. The number of years over which capital expenditures for each standard are expected to spread and the fractions of the expenditures for each of the years were specified.

g. For water categories, the percent of total capacity in each plant size class which discharges pretreated wastewater to municipal systems was specified.

h. Annual investments and O&M costs for the control of air emissions from mobile sources and electric utilities

were entered into the ABATE model exogenously for computation of feedback effects and aggregate air pollution abatement costs.

2. Municipal Wastewater Treatment Data. The following data was developed as inputs to ABATE for municipal wastewater treatment (Municipal expenditures for this report were exogenously expressed based on projected Government appropriations for sewage treatment facilities. The ABATE model was thus not used to calculate municipal costs, but the feedback features of SEAS were used to estimate the economic, employment, and energy impacts of these costs.):

- a. Population served by year per capita wastewater flow:
- b. Capital and O&M cost functions for primary and secondary treatment and the upgrading of secondary treatment:
- c. Percent of wastewater flow to each treatment type and the average plant size in each type:
- d. Percent of total population whose wastewater needs are either replacement or upgrading from primary to secondary and from secondary to tertiary, by year.

e. A similar collection of factors, percentages and cost curves for interceptor sewer costs, and for combined sewer overflow remedy costs; and

f. The wastewater flow generated by industries which divert their wastewater to municipal facilities for treatment.

The ABATE cost model uses the data discussed above to generate aggregated abatement costs for each industry and for municipal treatment facilities in a straightforward manner, as follows:

1. Industrial Abatement Costs. The model forecasts yearly capacity using growth rates calculated from the corresponding INFORUM sector or subsector. The capacity is distributed among the plant size classes as specified by the user and capital costs are calculated for the average plant in each class using the appropriate cost function (depending on the year and whether the plant must meet New Source Performance Standards). The model then sums costs across classes to get total capital costs for the year. For water categories, the model derives the costs using both the pretreatment and full treatment cost functions, depending on the fraction of capacity in each plant size class using municipal facilities. For these water categories, ABATE also calculates the total volume of wastewater discharged to

municipal facilities. Finally, the model uses equipment life and a 10 percent interest rate to annualize the capital costs.

ABATE performs a similar aggregation of operating and maintenance costs except that for existing plants, the expenditures do not begin until the compliance year is reached. Moreover, for these costs the model need not keep track of expenditures spread over several years as it must do for capital costs. The O&M costs calculated by ABATE for a given year create a demand for resources that is reflected through feedbacks which modify the output levels from the affected INFORUM sectors. In turn, these changed output levels result in different sector growth rates from which the abatement costs are recalculated for that year. ABATE and INFORUM are self-correcting as they use growth rates which are constantly being revised.

2. Municipal Abatement Costs. The municipal portion of ABATE calculates costs associated with building and upgrading treatment costs, with laying interceptor and collector sewer lines, and with the control of the combined sewer overflow problem. The wastewater flow needing treatment in any year is based on incremental flow from industrial dischargers to municipal systems and that part of the non-industrial flow that needs replacement or upgrading.

This flow is allocated to treatment type (primary, secondary, and upgrading to tertiary) Average plant sizes by type are then used to determine the number of new plants to be constructed. Capital and operating cost functions are used to determine total cost based on plants to be constructed and their average size. The amount of this cost fed back into INFORUM is adjusted by a user-specified factor indicating the proportion of this total not already accounted for in the INFORUM baseline. A similar procedure is used to determine costs for interceptor and collectors, and for correction of combined sewer overflow using incremental cost functions for these categories.

Annualized costs are partly allocated back to the industries based on their share of the total wastewater flow. Calculations of abatement expenditures for sewers and for the combined sewer overflow (CSO) problem is similar except that population needing sewers is distributed among city sizes, and population needing CSO correction is distributed among population groups. Hence, ABATE aggregate costs computed by city size and by population group to obtain total expenditures for sewers and the CSO problem, respectively.

For the pollution abatement scenarios run for this report, annual investments in municipal sewage treatment facilities

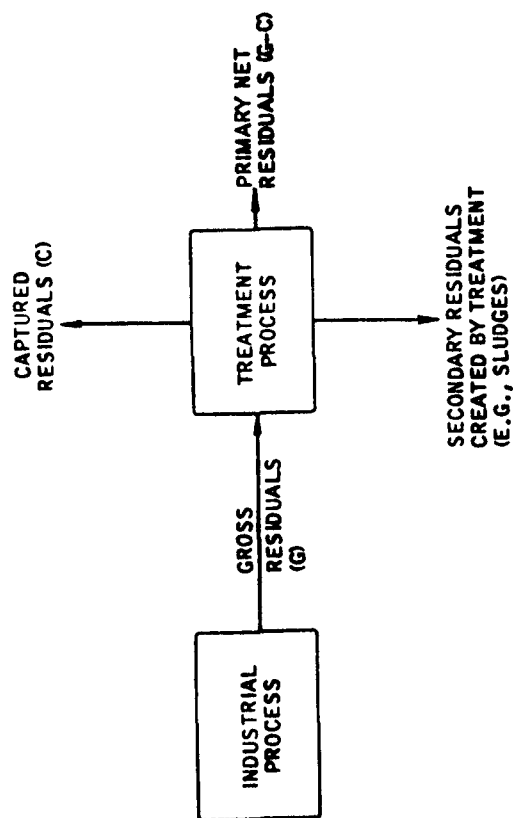
were exogenously specified, based on the total projected funds available from Federal, state, and local governments. The computations of annualized municipal treatment costs and user charges were thus constrained by anticipated funding limitations.

\$bTHE INDUSTRIAL ENVIRONMENTAL RESIDUALS MODEL (RESGEN)\$R

RESGEN estimates the annual national pollutant residuals associated with industrial, municipal treatment, and electric utility processes for six media: air, water, land, leachate, pesticides, and radiation. It does not estimate motor vehicle emissions, storm water run-off residuals, or emissions from nonpoint sources of pollution associated with land use activities, such as agriculture, forestry, mining and drilling, and construction. These are currently estimated outside of SEAS except for motor vehicle emissions, which are forecast by PIRANS and FTRANS. For all other significant polluting industries and utilities, RESGEN initially forecasts the gross pollutant emissions that would occur if no abatement activity had occurred pursuant to the 1970 Amendments to the Clean Air Act or the 1972 Amendments

to the Federal Water Pollution Control Act. Then it estimates the net emissions, assuming that some specified level of pollution abatement activity is occurring. The differences are the captured residuals which include recyclable wastes. RESGEN generates estimates of primary residuals and significant secondary residuals resulting from the pollution treatment processes themselves. (See FigureAA-3.)

Figure A-1.
Residue Estimation Process Flowchart



As in the case of ABATE, the input data used by RESGEN corresponds directly to the pollution emissions reductions discussed in the industry summaries in Sections Two and Three. The primary data comprises gross residual coefficients for specified years and associated fractions of total wasteload treated, average removal efficiencies, and rates at which waste materials are recycled as percentages of captured residuals.

\$bTHE TRANSPORTATION MODELS

(PTRANS AND FIRANS)\$R

The two transportation models, PTRANS and FIRANS, use annual forecasts of vehicle miles travelled by automobile, bus, truck, rail, commuter rail, and airplane to estimate the air pollution emissions for passenger transportation vehicles in six categories: hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides, lead, and particulates.

For a given calendar year, the PTRANS model uses the disposable income forecast by INFORUM and the population forecast to determine the number of new vehicles on the road. It uses data from the 1974 National Transportation

Study for vehicle miles travelled by transportation mode and occupancy ratios to distribute the VMT forecast among intracity (auto, bus, rapid transit, rail transit) and intercity (auto, air, bus, railroad) transportation modes. Then it uses EPA emissions factors to forecast gross and net residuals for the year. Gross residuals are those which would have occurred if EPA had not placed further regulations on motor vehicle emissions after 1971. Net residuals are those which occur as a result of compliance with post-1971 EPA regulation of motor vehicle emissions. In the case of automobiles, PTRANS also utilizes input data indicating the distribution of cars on the road by model year to forecast these residuals.

Freight ton-mile projections are computed by the FIRANS model by applying INFORUM growth rates for freight sectors to base year data drawn from Department of Transportation studies. Modal splits and occupancy ratios are then applied to develop forecasts of vehicle miles travelled for trucks, rail, water, air, and pipelines. Pollutant emissions are then estimated by applying emission factors to each mode.

\$bTHE ENERGY USE MODEL (ENERGY)\$R

ENERGY estimates energy use by fuel category based on INFORUM annual output forecasts for the 185 economic sectors. For each fuel category, it also reports whether the fuel is used for combustion or as a raw material feedstock by user category: industrial, commercial, residential, transportation, electric utility consumption, and electricity generation. The model provides a detailed accounting of all fuel usage in quadrillions (10¹²) of Btu's based on the interindustry relationships in INFORUM at the time the sector output forecasts are made.

Because the energy forecasts are based on the INFORUM annual outputs, the supply constraints caused by relative price adjustments are introduced into the forecasts. The relative price adjustments might have resulted from changed fuel stock levels (STOCKS model) or from pollution abatement feedback into INFORUM (ABATE model). Consequently, ENERGY is sensitive to a wide range of conservation and abatement assumptions.

\$bTHE STOCKS RESERVES AND PRICES

MODEL (STOCKS)\$R

The STOCKS model in SEAS provides information on raw material sources, reserve levels, and relative production costs for alternative assumptions regarding import, export, and inventory levels. The model maintains accounts on both domestic and world-wide reserves as a function of relative production price. Currently, twelve stock categories are covered, of which six are fuels and six are non-fuel minerals. Overrides for prices, investments, imports, and exports are generated by STOCKS as optional feedbacks to the national economic models.

\$bTHE SOLID WASTE AND RECYCLING

MODEL (SOLRECYC)\$R

The SEAS SOLRECYC model estimates the annual tonnage of solid waste generated from non-industrial sources, the expected proportional use of disposal method, and the costs associated with each method. The model also projects

estimated levels of recycling, which are fed to the STOCKS model for adjustment of raw material demands.

\$bTHE SUMMARY REPORT GENERATORS
(POSTCOMP, INFRPT AND CLEANSUM)\$R

As shown in Figure A-1, each of the special-purpose models named above produces its own detailed output report. In addition to these detailed reports, summarized data from these models, as well as from the national economic program, are collected in a common data file for production of summary reports. Three types of report generators were used to support the assessment of pollution control impacts:

- POSTCOMP, which provides annual values and annualized percentage changes for significant parameters from every SEAS model, as well as comparative indexes for pollutant residuals from up to four scenarios.
- INFRPT, which provides comparative sector rankings and percentage differences in INFORUM economic results for selected scenario pairs:

- CLEANSUM, which provides annual abatement costs and residuals for each SEAS economic sector

Run books for all scenarios described in this Section are maintained on file at EPA. These books contain both the detailed model outputs as well as the summary reports produced for each scenario.

Appendix B

Scenario Assumptions

REFERENCE SCENARIO

The scenario approach requires that a set of assumptions, constituting a baseline or Reference Scenario, be developed for comparative analysis purposes. The consequences of alternative assumptions concerning public policy can then be measured against this baseline. The purpose of the Reference Scenario is thus to establish a useful benchmark for comparative analysis; it is not intended to provide predictions of the most probable future.

The Reference Scenario is based on assumptions about future trends and policies from 1976 through 1985. These assumptions, in general, represent official forecasts of the future made by appropriate government agencies in their specific areas of responsibility (e.g., population growth by the Bureau of the Census). Table B-1 presents the names of the government agencies from which these forecasts were obtained. Where appropriate, the values for these forecasts are also given.

Table B-1.
Reference Scenario Assumptions

\$t	Assumption	Government Agency	Values
	Population-Series E Projections (Millions of People)	Department of Commerce, Bureau of the Census	1975-213.9 1980-224.1 1985-235.7
	Labor Force (Millions of People)	Department of Labor, Bureau of Labor Statistics	1975- 93.8 1980-101.8 1985-107.7
	Labor Productivity	Bureau of Labor Statistics	Varies by Industry
	Gross National Product (Trillions of 1975 Dollars)	Ford/Council of Economic Advisors (1975-1980) Bureau of Labor Statistics (1980-1985)	1975-1.47 1976-1.57 1977-1.69 1978-1.81 1979-1.85 1980-1.99 1985-2.40
	Forecast Time Period	EPA	1/1/76-12/31/85
	Unemployment Rate in 1985 (Full Employment Economy)	Bureau of Labor Statistics	4.0 to 4.5%
	Federal Expenditures in 1980 and 1985 Excluding Transfers and Pollution Control Programs (Millions 1975 Dollars)	Department of Commerce, Bureau of Economic Analysis	1980-156.400 1985-173.400
	Federal Expenditures for Pollution Control\$R	EPA	

The GNP and unemployment rate estimates selected for the Reference Scenario are intended to represent the current best estimates of what can be achieved nationally between the present and 1985, through a combination of public sector

monetary and fiscal policy. The Reference Scenario target objectives for these variables for 1976 through 1985 represent a combination of the Council of Economic Advisors (CEA) and U.S. Office of Management and Budget (OMB) forecasts for the near-in period through 1980, and the Bureau of Labor Statistics (BLS) projected economic growth for the 1981-1985 period, as contained in The Structure of the U_S_ Economy in 1980 and 1985 (U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 1831, op_cit_). Assumptions about labor force and labor productivity are those contained in the BLS projections with the greatest long-run likelihood based upon GNP supply-oriented (or potential) concepts, since these are tempered by personal income, demand, and demographic change considerations.

A steadily declining unemployment rate through the forecast period is required to be consistent with the GNP forecasts and assumptions about labor force and productivity. The Reference Scenario thus uses an unemployment rate which declines monotonically over the period from the high rates of the mid-1970's to a rate between 4.0 and 4.5 percent in the mid-1980's. The annual changes in productivity assumed in the Reference Scenario are those assumed in the BLS projections (Structure of the U_S_ Economy in 1980 and 1985, op_cit_ Chapters 1 and 2 and Appendix A). These assumptions replace, for the Reference Scenario, those

originally used in the INFORUM projections (Almon, et al., 1985: Interindustry Forecasts of the American Economy, op.cit., Chapter 1).

The Reference Scenario assumptions also include the setting of Federal expenditures for non-pollution-control activities in 1975 dollars (excluding transfers) at \$156,400 million in 1980 (\$106,060 million and \$50,340 million, defense and non-defense, respectively) and \$173,400 million in 1985 (\$115,200 million and \$58,200 million, defense and non-defense, respectively), with interpolations for intervening years. In addition, personal disposable income per capita is adjusted to meet the desired GNP and unemployment targets specified above.

The Reference Scenario represents a calibration of the SEAS system to the assumed GNP projections and unemployment rates in the absence of pollution control expenditures induced by Federal legislation. This does not mean that there are no pollution control expenditures implied in the Reference Scenario because there are substantial levels of such investments which would have been incurred in the absence of legislated abatement policies.

The Reference Scenario is intended to reflect neither an unusually high energy consumption rate nor an unrealistic

energy conservation effort. The energy consumption assumptions contained in the Federal Energy Administration's Project Independence report for the "Business as Usual" case, with oil at \$7 per barrel, were thus used in the Scenario. The assumptions are summarized in Table B-2 in terms of the projected total gross consumption of energy resources in trillions of Btu's by fuel source.

Table B-2.
United States Total Gross Consumption of
Energy Resources (in Trillions of Btu's/Year)
(Business-as-Usual Without Conservation - \$7/Bbl Oil)

Fuel	1972	\$t 1977	1980	1985
Coal	12.495	16.854	18.074	19.888
Petroleum	32.966	37.813	41.595	47.918
Natural Gas	23.125	21.558	22.934	23.947
Nuclear Power	576	2.830	4.842	12.509
Other	2.946	3.543	4.014	4.797
Totals	72.108	82.598	91.459	109.059

Source: Project Independence Report, Federal Energy Administration, Appendix A1, p.37, November 1974.\$R

\$REFERENCE ABATEMENT SCENARIO\$R

The Reference Abatement Scenario differs from the Reference Scenario in that it includes the incremental pollution control practices, with their attendant employment and costs, necessary to achieve compliance with Federal legislation. Most of the unit cost data used for calculation of these costs in SEAS was provided in constant 1973 dollars. Since the INFORUM data is currently expressed in constant 1971 dollars, it was necessary to first deflate the input values from 1973 to 1971 dollars, and then to inflate the computed results back to 1975 dollars for presentation in this report. The deflation and inflation factors used for these purposes are presented in Table B-3.

Abatement costs are computed and analyzed in terms of annual investment, annual O&M costs, annualized capital costs, capital-in-place, and number of employees directly engaged in pollution control activities. Total annual costs are computed as the sum of annual O&M costs and annualized capital costs. The annualized capital costs are derived by applying a capital recovery factor to the annual investment amounts. This factor has the form of:

$$\frac{NSe}{1(1+i)^{50}}$$

$$\frac{NSe}{(1+i)^N} - 1SR$$

where "i" is the annual interest rate expressed as a fraction and "N" is the life of the abatement equipment in years. For these calculations, a nominal interest rate of 10 percent is assumed for both the private and public sectors. Abatement equipment life varies with the type of control technology being applied.

Table B-3
Summary of Inflation and Deflation Factors

Type of Abatement Cost	Sources	Capital 1973-71	1971-75	O&M 1973-71	1971-75
Water	Engineering News Record	0.879	1.330	0.898	1.295
Air-Electrostatic Precipitator	Joy Manufacturing Co., Nelson Electricity Cost Index	0.708	2.136	0.909	1.718
Air-Building Evacuation	Chemical Engineering Plant Cost Index, Nelson Electricity Cost Index	0.943	1.541	0.909	1.718
Air-Fuel Switching, Afterburners, Incinerators	Chemical Engineering Plant Cost Index, Nelson Fuel Cost Index	0.943	1.541	0.892	2.138
Air-All Other Equipment	Chemical Engineering Plant Cost Index, Nelson Operating Cost Index	0.943	1.541	0.939	1.533

A General GNP Inflation Rate of 1.311 was used to convert GNP estimates from 1971 to 1975 dollars (Source: Bureau of Labor Statistics)

Federal expenditures and non-defense Federal employment are both incremented to account for Federally-funded pollution control programs and activities. These increments are presented in Table B-4.

Table B-4.
Federal Expenditure and Employment Increments for
Reference Abatement Scenario

\$t	1985
Federal Expenditure Increment	
Non-Defense (Millions of 1975 Dollars)	+2.564
Defense (Millions of 1975 Dollars)	+384
Federal Employment Increment	
-(Millions of People)	+0.25R

Unemployment rates were calibrated in the Reference Scenario to near full-employment levels of 4.0 to 4.5 percent during the 1980's. The addition of pollution control investment capital, employment, and Federal expenditures thus tends to drive unemployment below these levels. When this occurs, the per capital disposable income is constrained to reflect a typical inflation dampening fiscal policy. The scenario is then run again until unemployment is equal to or greater than 4.0 percent.

The Reference Abatement Scenario assumes that all sources of pollution will fully comply with the EPA and state regulations and guidelines developed in response to the Clean Air Act of 1970 and the 1972 Amendments to the Federal

Water Pollution Control Act. Detailed compliance assumptions may be found in Section 2 (Air) and Section 3 (Water) of this report.

\$BLOW PRODUCTIVITY SCENARIOS\$R

The Low Productivity and Low Productivity Abatement Scenarios differ from their Reference Case counterparts in that they make use of the productivity functions and growth assumptions contained in the INFORUM model as obtained from the University of Maryland. Compared with the Reference Scenarios, they reflect a slowing down of productivity because of shifts toward service industries in the pattern of final demand, and because of a slowing down of the productivity increase rates in other industries. GNP estimates which correspond to these assumptions are shown in Table B-5 compared with those for the Reference Scenario.

Table B-5.
Comparison of GNP Estimates for
Low Productivity and Reference Scenarios
(in Trillions of 1975 Dollars)

	Low Productivity GNP	Reference Case GNP
1975	1.52	1.52
1977	1.66	1.66
1980	1.84	2.00
1983	1.99	2.15
1985	2.09	2.363R

ASSUMPTIONS FOR THE ENERGY
AND ENERGY ABATEMENT SCENARIOS

The two Energy Conservation scenarios approximate energy usage forecasts in the Federal Energy Administration's "Business-as-Usual with Conservation" scenario where the import price of oil is \$11 per barrel. (See Appendix A1, page 46 of the November 1974 Project Independence Report-- The energy consumption estimates in the Energy and Energy Abatement Scenarios each reflect a net reduction of approximately 15 quadrillion Btu's compared with their corresponding Reference Case scenarios. The following types of changes were introduced to achieve these energy savings:

1. A reduction in the household consumption of fossil fuels for heating to simulate raising the thermostat setting in the summer and lowering it in the winter.
2. A reduction in personal consumption expenditures for gasoline to simulate increased carpooling (with an automobile occupancy of 1.96 persons per vehicle as compared to the Reference Occupancy factor of 1.56). Increased shifts to mass transit are included for the Energy Conservation Scenario, such as a model split comparison for 1985 as shown below:

St

Intracity	Reference	Energy
Auto	0.9070	0.8690
Bus	0.0230	0.0610
Rapid	0.0350	0.0350
Rail	0.0350	0.0350
Intercity	Reference	Energy
Auto	0.8650	0.8250
Air	0.0950	0.0950
Bus	0.0300	0.0500
Rail	0.0100	0.0300\$R

3. A reduction in the interindustry fossil fuel use coefficients for energy-intensive products as inputs to production by substitution of less energy-intensive inputs. These measures include: shifts to returnable beverage containers, reductions in the use of artificial fertilizers, reduced use of packaging

materials, and some recycling of energy-intensive materials.

4. Miscellaneous changes to reflect improved energy housekeeping activities.

See Appendix C.

Impact of Increased Federal

Grants for Municipal

Wastewater Treatment

A companion scenario to the Reference Abatement Scenario was made that held the Federal grant program for municipal wastewater treatment at \$7 billion per year through 1977-85. The comparative outlay data for the two scenarios is provided in Table 3-14 of Section Three. For this report, the scenario is identified as the Municipal Scenario.

Table C-1 provides a summary of relative macroeconomic impacts from the Reference Abatement Scenario to the Municipal Scenario; the primary statistics show only small differences between them. The additional funds to the economy operating at full-supply-GNP required that the disposable income per capita should be reduced from 1980 to 1985 on the order of 0.45 percent, which reduced personal consumption expenditures on the order of 0.35 percent. The primary large changes occur where expected, in state and local health and welfare expenditures growing to 12.0 percent in 1985 and stimulating public construction to 10.5 percent in 1985.

Table C-1.
Comparison of the Macro-Statistics of the Additional Municipal
Funding Scenario (2A) and the Reference Baseline Scenario (S2)
[(S2A-S2)/S2 in %]

Statistic	1975	1977	1980	1983	1985
Gross National Product	0.00	0.03	0.20	0.31	-0.01
Disposable Income Per Capita	0.00	0.00	-0.37	-0.46	-0.44
Federal Expenditures	0.00	0.00	0.00	0.00	0.00
Personal Consumption Expenditures	0.00	0.00	-0.27	-0.37	-0.38
Total Output	0.00	0.02	0.22	0.34	-0.03
Manufacturing	0.00	0.03	0.31	0.53	0.05
Investment	0.00	0.02	0.18	0.31	-0.27
State/Local Health & Welfare	0.00	0.04	2.98	9.43	12.04
Public Construction	0.04	0.69	13.54	20.14	10.54
Net Water Residuals	0.00	0.07	-3.33	-9.15	-14.55
Biochemical Oxygen Demand	0.00	0.07	-2.32	-8.26	-15.51
Suspended Solids	0.00	0.01	0.09	0.21	0.06
Dissolved Solids	0.00	0.00	-9.81	-24.15	-37.93
Nutrients					
Water Municipal Costs					
Annualized Costs	0.00	1.93	30.40	94.58	124.27
Capital	0.00	0.66	29.88	95.71	125.90
O&M	0.00	1.93	30.40	94.58	124.27
Capital in Place	0.00	0.65	26.34	95.83	125.90
Direct Employment					\$

3aAppendix D.
Estimating the Cost For
Industries to Control
Pollution\$R

Industrial facilities are required to control their air pollution emissions if they are so regulated by a State Implementation Plan (SIP) or by Federal New Source Performance Standards (NSPS). States are obliged by the Clean Air Act to specify the emission controls required by each industrial sector to achieve the Federal ambient air quality standards throughout the state.

For new plants, the interregional treatment is more identical because Federal Air NSPS's apply to plants built or extensively modified after the particular NSPS guideline for that industry is promulgated. As of August 1975, NSPS's have been published for 17 industries. The NSPS allowable emission levels are usually lower than those for existing sources; hence, quite often unit control costs for plants regulated by NSPS are greater than for plants regulated by SIP's.

The deadline for meeting the Federal ambient standards was July 1, 1975. Industries have not yet made the expenditures required to achieve their part of the emissions reduction necessary to meet ambient standards. Industries are continuing to install air pollution abating equipment.

however, and for the purposes of this report, it was assumed that the required air abating investment will be made by the end of 1978. It is also assumed that BPT standards for water pollution control will be met in 1977, and that BAT compliance will be achieved in 1983.

When air and water controls are taken together, seventy-two industrial sectors have significant control costs. The number of sectors within each aggregate industry classification is shown in Table D-1.

Table D-1.
Distribution of Industrial Cost-Control Sectors

Aggregate Industry	Total Industrial Sectors	Air Cost Sectors	Water Cost Sectors
Agriculture	1	0	1
Mining	3	3	0
Food Processing	9	1	8
Textiles	2	0	2
Paper & Lumber	6	2	5
Chemicals	12	6	6
Petroleum	3	3	1
Rubber	1	0	1
Ferrous Metals	4	4	2
Nonferrous Metals	9	8	7
Stone, Clay, Glass	8	5	5
Machinery & Equipment	5	1	4
Steam Electric	1	1	1
Trade & Services	2	2	0
Miscellaneous	6	5	1
Total	72	41	44

But this listing does not provide a good appreciation for the detail at which the abatement cost estimates are made.

For example, the steel-making industry, for purposes of air pollution control, is a single item under Ferrous Metals in the above table, but actually 22 different industrial segments are defined, each with its own cost curve for capital expenditure and O&M as a function of plant size. There are 497 industrial segments for which air or water control costs are estimated.

\$B INDUSTRIAL SEGMENTS SR
\$B MODEL PLANTS, UNIT COSTS AND GROWTH \$R

In order to calculate pollution control costs, industries are represented by "segments" and "model plants". A "segment" is all or a portion of an industry that has (1) the same production process, (2) the same pollution control technology, and (3) the same pollution control standard. For example, the Kraft Paper Industry is dealt with for purposes of air pollution control costs in terms of 10 different segments. These segments are defined and numbered in Table D-2. "Model plants" are the building blocks of a segment; that is, a segment's capacity for production is comprised of a number of model plants that are classified as either "existing" or "new" (new facilities are

those constructed after the date when the Clean Air Act or Clean Water Act affects that industry) For example, Segment 7 for Kraft Paper (Smelting Tanks) has three model plant sizes (454, 907, and 1,361 units of production per day). There are existing facilities in all three sizes, but during the 1975-85 period, new facilities are expected to be built in only the middle-size class.

The cost of controlling air pollution from industrial sources is estimated for model plants. All existing capacity is expressed in terms of the model plants, and all new growth in capacity is also expressed in terms of these model plants. For example, the smallest model plant in Segment 7 for Kraft Paper has to spend \$54,000 for capital equipment to control particulates.

Table D-2.
Kraft Paper Industry Segment Definitions

Process	Control Technology	Pollution Standard
1. Power Boiler	Electrostatic Precipitators	Federal Particulates
2. Boiler	Double Alkali Scrubber	Federal Sulfur Dioxide
3. Recovery Furnace	Electrostatic Precipitators	Washington/Oregon Particulates
4. Recovery Furnace	Venturi Scrubber	Washington, Oregon Particulates
5. Recovery Furnace	Recovery Furnace Replacement	Washington/Oregon Total Reduced Sulfur
6. Recovery Furnace	Black Liquor Oxidation	Washington/Oregon Total Reduced Sulfur
7. Smelting Tank	Orifice Scrubber	Washington/Oregon Particulates
8. Lime Kiln	Venturi Scrubber	Washington/Oregon Particulates
9. Stock Washer	Incinerate in Recovery Furnace	Washington/Oregon Total Reduced Sulfur
10. Evaporator	Incinerate in Lime Kiln	Washington/Oregon Total Reduced Sulfur

Each industrial segment has a capital cost equation and an O&M cost equation that states dollar costs as a function of plant capacity or water use. The air cost equations are derived from individual studies funded by EPA (see Section Two) and the water costs are obtained from the EPA Development Documents (see Section Three).

Each industry segment is associated with one of the 185 industrial aggregate sectors of the economic I/O table via a side equation as explained earlier. (See Table D-3 for the aggregate industry sectors and Table D-4 for the detailed subsectors.) Therefore, the growth of capacity or water use (and the accompanying growth in abatement costs) in each segment is dependent upon the dynamics of the inter-industry model. Thus, if a model user decreases the personal consumption purchases of automobiles, then the direct and indirect effects of this reduction in car sales will ripple throughout the system. The abatement costs for steel industries, aluminum industries and other industries indirectly impacted by the car sales change will be calculated. In the same manner, additional purchases by a sector required for pollution control can be imposed and the direct and indirect impacts are catalogued.

4871
4872
4873

103 OFFICE SUPPLIES DUMMAY (AMMND) 5717 JGN 5 31 40

4677
4878
4379

6-9

SaAppendix C.

Impact of Increased Federal

Grants for Municipal

Wastewater Treatment\$R

A companion scenario to the Reference Abatement Scenario was made that held the Federal grant program for municipal wastewater treatment at \$7 billion per year through 1977-85. The comparative outlay data for the two scenarios is provided in Table 3-14 of Section Three. For this report, the scenario is identified as the Municipal Scenario.

Table C-1 provides a summary of relative macroeconomic impacts from the Reference Abatement Scenario to the Municipal Scenario; the primary statistics show only small differences between them. The additional funds to the economy operating at full-supply-GNP required that the disposable income per capita should be reduced from 1980 to 1985 on the order of 0.45 percent, which reduced personal consumption expenditures on the order of 0.35 percent. The primary large changes occur where expected. In state and local health and welfare expenditures growing to 12.0 percent in 1985 and stimulating public construction to 10.5 percent in 1985.

\$dTable C-1.
Comparison of the Macro-Statistics of the Additional Municipal
Funding Scenario (2A) and the Reference Abatement Scenario (S2)
[(S2A-S2)/S2 in %]

Statistic	1975	1977	1980	1983	1985
Gross National Product	0.00	0.03	0.20	0.31	-0.01
Disposable Income Per Capita	0.00	0.00	-0.37	-0.46	-0.44
Federal Expenditures	0.00	0.00	0.00	0.00	0.00
Personal Consumption Expenditures	0.00	0.00	-0.27	-0.37	-0.38
Total Output	0.00	0.02	0.22	0.34	-0.03
Manufacturing	0.00	0.03	0.31	0.53	0.05
Investment	0.00	0.02	0.18	0.31	-0.27
State&Local Health & Welfare	0.00	0.04	2.98	9.43	12.04
Public Construction	0.04	0.69	13.54	20.14	10.54
Net Water Residuals	0.00	0.01	-3.33	-9.15	-14.55
Biochemical Oxygen Demand	0.00	0.07	-2.32	-8.26	-15.51
Suspended Solids	0.00	0.01	0.09	0.21	0.06
Dissolved Solids	0.00	0.00	-9.81	-24.15	-37.93
Nutrients					
Water Municipal Costs					
Annualized Costs					
Capital	0.00	1.93	30.40	94.58	124.27
O&M	0.00	0.66	29.88	95.71	125.90
Capital in Place	0.00	1.93	30.40	94.58	124.27
Direct Employment	0.00	0.65	26.34	95.83	125.90\$s

§aAppendix D.
Estimating the Cost For
Industries to Control
Pollution§R

Industrial facilities are required to control their air pollution emissions if they are so regulated by a State Implementation Plan (SIP) or by Federal New Source Performance Standards (NSPS). States are obliged by the Clean Air Act to specify the emission controls required by each industrial sector to achieve the Federal ambient air quality standards throughout the state.

For new plants, the interregional treatment is more identical because Federal Air NSPS's apply to plants built or extensively modified after the particular NSPS guideline for that industry is promulgated. As of August 1975, NSPS's have been published for 17 industries. The NSPS allowable emission levels are usually lower than those for existing sources; hence, quite often unit control costs for plants regulated by NSPS are greater than for plants regulated by SIP's.

The deadline for meeting the Federal ambient standards was July 1, 1975. Industries have not yet made the expenditures required to achieve their part of the emissions reduction necessary to meet ambient standards. Industries are continuing to install air pollution abating equipment.

however, and for the purposes of this report, it was assumed that the required air abating investment will be made by the end of 1978. It is also assumed that BPT standards for water pollution control will be met in 1977, and that BAT compliance will be achieved in 1983.

When air and water controls are taken together, seventy-two industrial sectors have significant control costs. The number of sectors within each aggregate industry classification is shown in Table D-1.

Table D-1.
Distribution of Industrial Cost-Control Sectors

Aggregate Industry	Total Industrial Sectors	Air Cost Sectors	Water Cost Sectors
Agriculture	1	0	1
Mining	3	3	0
Food Processing	9	1	8
Textiles	2	0	2
Paper & Lumber	6	2	5
Chemicals	12	6	6
Petroleum	3	3	1
Rubber	1	0	1
Ferrous Metals	4	4	2
Nonferrous Metals	9	8	7
Stone, Clay, Glass	8	5	5
Machinery & Equipment	5	1	4
Steam Electric	1	1	1
Trade & Services	2	2	0
Miscellaneous	6	5	1
Total	72	41	44SR

But this listing does not provide a good appreciation for the detail at which the abatement cost estimates are made.

For example, the steel-making industry, for purposes of air pollution control, is a single item under Ferrous Metals in the above table, but actually 22 different industrial segments are defined, each with its own cost curve for capital expenditure and O&M as a function of plant size. There are 497 industrial segments for which air or water control costs are estimated.

\$bINDUSTRIAL SEGMENTS:SR

\$bMODEL PLANTS, UNIT COSTS AND GROWTH\$R

In order to calculate pollution control costs, industries are represented by "segments" and "model plants". A "segment" is all or a portion of an industry that has (1)the same production process, (2)the same pollution control technology, and (3)the same pollution control standard. For example, the Kraft Paper Industry is dealt with for purposes of air pollution control costs in terms of 10 different segments. These segments are defined and numbered in Table D-2. "Model plants" are the building blocks of a segment; that is, a segment's capacity for production is comprised of a number of model plants that are classified as either "existing" or "new" (new facilities are

those constructed after the date when the Clean Air Act or Clean Water Act affects that industry). For example, Segment 7 for Kraft Paper (Smelting Tanks) has three model plant sizes (454, 907, and 1,361 units of production per day). There are existing facilities in all three sizes, but during the 1975-85 period, new facilities are expected to be built in only the middle-size class.

The cost of controlling air pollution from industrial sources is estimated for model plants. All existing capacity is expressed in terms of the model plants, and all new growth in capacity is also expressed in terms of these model plants. For example, the smallest model plant in Segment 7 for Kraft Paper has to spend \$54,000 for capital equipment to control particulates.

Table D-2.
Kraft Paper Industry Segment Definitions

\$t	Process	Control Technology	Pollution Standard
1.	Power Boiler	Electrostatic Precipitators	Federal Particulates
2.	Boiler	Double Alkali Scrubber	Federal Sulfur Dioxide
3.	Recovery Furnace	Electrostatic Precipitators	Washington/Oregon Particulates
4.	Recovery Furnace	Venturi Scrubber	Washington/Oregon Particulates
5.	Recovery Furnace	Recovery Furnace Replacement	Washington/Oregon Total Reduced Sulfur
6.	Recovery Furnace	Black Liquor Oxidation	Washington/Oregon Total Reduced Sulfur
7.	Smelting Tank	Orifice Scrubber	Washington/Oregon Particulates
8.	Lime Kiln	Venturi Scrubber	Washington/Oregon Particulates
9.	Stock Washer	Incinerate in Recovery Furnace	Washington/Oregon Total Reduced Sulfur
10.	Evaporator	Incinerate in Lime Kiln	Washington/Oregon Total Reduced Sulfur

Each industrial segment has a capital cost equation and an O&M cost equation that states dollar costs as a function of plant capacity or water use. The air cost equations are derived from individual studies funded by EPA (see Section Two) and the water costs are obtained from the EPA Development Documents (see Section Three).

Each industry segment is associated with one of the 185 industrial aggregate sectors of the economic I/O table via a side equation as explained earlier. (See Table D-3 for the aggregate industry sectors and Table D-4 for the detailed subsectors.) Therefore, the growth of capacity or water use (and the accompanying growth in abatement costs) in each segment is dependent upon the dynamics of the interindustry model. Thus, if a model user decreases the personal consumption purchases of automobiles, then the direct and indirect effects of this reduction in car sales will ripple throughout the system. The abatement costs for steel industries, aluminum industries and other industries indirectly impacted by the car sales change will be calculated. In the same manner, additional purchases by a sector required for pollution control can be imposed and the direct and indirect impacts are catalogued.

4367
4467
4567

Table D-1.
The 185 Industrial Sectors in the
Input-Output Table of INFROM

1	SEMI-CONDUCTORS	2	POULTRY AND EGGS	3	MEAT ANIMALS, OTM LIVESTK
4	CRIMINAL PRODUCTS	5	COAL	6	TOBACCO
7	ALL OTHERS, OTM CROPS	8	PHARMACY AND FISHERY PROD.	9	NO USE
10	ALL OTHERS, FISH SERVICE	11	ISOLATED	12	COPPER ORE
13	CRUDE PETROLEUM	14	COAL MINING	15	CRUDE PETROLEUM, NAT. GAS
16	STEEL AND CAST IRON	17	CRUDE PETROLEUM, NAT. GAS	18	NEW CONSTRUCTION
19	CONSTRUCTION	20	CRUDE PETROLEUM, NAT. GAS	21	CRUDE PETROLEUM
22	CRUDE PETROLEUM	23	CRUDE PETROLEUM, NAT. GAS	24	CRUDE PETROLEUM
25	CRUDE PETROLEUM	26	CRUDE PETROLEUM, NAT. GAS	27	CRUDE PETROLEUM
28	CRUDE PETROLEUM	29	CRUDE PETROLEUM, NAT. GAS	30	CRUDE PETROLEUM
31	CRUDE PETROLEUM	32	CRUDE PETROLEUM, NAT. GAS	33	CRUDE PETROLEUM
34	CRUDE PETROLEUM	35	CRUDE PETROLEUM, NAT. GAS	36	CRUDE PETROLEUM
37	CRUDE PETROLEUM	38	CRUDE PETROLEUM, NAT. GAS	39	CRUDE PETROLEUM
40	CRUDE PETROLEUM	41	CRUDE PETROLEUM, NAT. GAS	42	CRUDE PETROLEUM
43	CRUDE PETROLEUM	44	CRUDE PETROLEUM, NAT. GAS	45	CRUDE PETROLEUM
46	CRUDE PETROLEUM	47	CRUDE PETROLEUM, NAT. GAS	48	CRUDE PETROLEUM
49	CRUDE PETROLEUM	50	CRUDE PETROLEUM, NAT. GAS	51	CRUDE PETROLEUM
52	CRUDE PETROLEUM	53	CRUDE PETROLEUM, NAT. GAS	54	CRUDE PETROLEUM
55	CRUDE PETROLEUM	56	CRUDE PETROLEUM, NAT. GAS	57	CRUDE PETROLEUM
58	CRUDE PETROLEUM	59	CRUDE PETROLEUM, NAT. GAS	60	CRUDE PETROLEUM
61	CRUDE PETROLEUM	62	CRUDE PETROLEUM, NAT. GAS	63	CRUDE PETROLEUM
64	CRUDE PETROLEUM	65	CRUDE PETROLEUM, NAT. GAS	66	CRUDE PETROLEUM
67	CRUDE PETROLEUM	68	CRUDE PETROLEUM, NAT. GAS	69	CRUDE PETROLEUM
70	CRUDE PETROLEUM	71	CRUDE PETROLEUM, NAT. GAS	72	CRUDE PETROLEUM
73	CRUDE PETROLEUM	74	CRUDE PETROLEUM, NAT. GAS	75	CRUDE PETROLEUM
76	CRUDE PETROLEUM	77	CRUDE PETROLEUM, NAT. GAS	78	CRUDE PETROLEUM
79	CRUDE PETROLEUM	80	CRUDE PETROLEUM, NAT. GAS	81	CRUDE PETROLEUM
82	CRUDE PETROLEUM	83	CRUDE PETROLEUM, NAT. GAS	84	CRUDE PETROLEUM
85	CRUDE PETROLEUM	86	CRUDE PETROLEUM, NAT. GAS	87	CRUDE PETROLEUM
88	CRUDE PETROLEUM	89	CRUDE PETROLEUM, NAT. GAS	90	CRUDE PETROLEUM
91	CRUDE PETROLEUM	92	CRUDE PETROLEUM, NAT. GAS	93	CRUDE PETROLEUM
94	CRUDE PETROLEUM	95	CRUDE PETROLEUM, NAT. GAS	96	CRUDE PETROLEUM
97	CRUDE PETROLEUM	98	CRUDE PETROLEUM, NAT. GAS	99	CRUDE PETROLEUM
100	CRUDE PETROLEUM	101	CRUDE PETROLEUM, NAT. GAS	102	CRUDE PETROLEUM
103	CRUDE PETROLEUM	104	CRUDE PETROLEUM, NAT. GAS	105	CRUDE PETROLEUM
106	CRUDE PETROLEUM	107	CRUDE PETROLEUM, NAT. GAS	108	CRUDE PETROLEUM
109	CRUDE PETROLEUM	110	CRUDE PETROLEUM, NAT. GAS	111	CRUDE PETROLEUM
112	CRUDE PETROLEUM	113	CRUDE PETROLEUM, NAT. GAS	114	CRUDE PETROLEUM
115	CRUDE PETROLEUM	116	CRUDE PETROLEUM, NAT. GAS	117	CRUDE PETROLEUM
118	CRUDE PETROLEUM	119	CRUDE PETROLEUM, NAT. GAS	120	CRUDE PETROLEUM
121	CRUDE PETROLEUM	122	CRUDE PETROLEUM, NAT. GAS	123	CRUDE PETROLEUM
124	CRUDE PETROLEUM	125	CRUDE PETROLEUM, NAT. GAS	126	CRUDE PETROLEUM
127	CRUDE PETROLEUM	128	CRUDE PETROLEUM, NAT. GAS	129	CRUDE PETROLEUM
130	CRUDE PETROLEUM	131	CRUDE PETROLEUM, NAT. GAS	132	CRUDE PETROLEUM
133	CRUDE PETROLEUM	134	CRUDE PETROLEUM, NAT. GAS	135	CRUDE PETROLEUM
136	CRUDE PETROLEUM	137	CRUDE PETROLEUM, NAT. GAS	138	CRUDE PETROLEUM
139	CRUDE PETROLEUM	140	CRUDE PETROLEUM, NAT. GAS	141	CRUDE PETROLEUM
142	CRUDE PETROLEUM	143	CRUDE PETROLEUM, NAT. GAS	144	CRUDE PETROLEUM
145	CRUDE PETROLEUM	146	CRUDE PETROLEUM, NAT. GAS	147	CRUDE PETROLEUM
148	CRUDE PETROLEUM	149	CRUDE PETROLEUM, NAT. GAS	150	CRUDE PETROLEUM
151	CRUDE PETROLEUM	152	CRUDE PETROLEUM, NAT. GAS	153	CRUDE PETROLEUM
154	CRUDE PETROLEUM	155	CRUDE PETROLEUM, NAT. GAS	156	CRUDE PETROLEUM
157	CRUDE PETROLEUM	158	CRUDE PETROLEUM, NAT. GAS	159	CRUDE PETROLEUM
160	CRUDE PETROLEUM	161	CRUDE PETROLEUM, NAT. GAS	162	CRUDE PETROLEUM
163	CRUDE PETROLEUM	164	CRUDE PETROLEUM, NAT. GAS	165	CRUDE PETROLEUM
166	CRUDE PETROLEUM	167	CRUDE PETROLEUM, NAT. GAS	168	CRUDE PETROLEUM
169	CRUDE PETROLEUM	170	CRUDE PETROLEUM, NAT. GAS	171	CRUDE PETROLEUM
172	CRUDE PETROLEUM	173	CRUDE PETROLEUM, NAT. GAS	174	CRUDE PETROLEUM
175	CRUDE PETROLEUM	176	CRUDE PETROLEUM, NAT. GAS	177	CRUDE PETROLEUM
178	CRUDE PETROLEUM	179	CRUDE PETROLEUM, NAT. GAS	180	CRUDE PETROLEUM

4871
4872
4873

Table D-4.
The Industrial Subsectors in the
Input-Output Table of INPOPJM

181 NON-CONSUMPTIVE INDUSTRIES		182 BUSINESS TRAVEL (DUMY)		183 OFFICE SUPPLIES (DUMY)	
184 UNIMPORTANT INDUSTRIES (DUMY)		185 COMPUTED REVENUES (DUMY)			
SUBSECTOR NAMES					
1 3 BEEF LITTLE EFF. PLTS	5 1 CORN	5 2 SOYBEANS			
2 3 MILK	7 1 APPLES	7 2 POTATOES			
3 3 CITS	9 1 MUNICIPAL SWAGE	9 2 WATER WAGED PAINTS CONSUMPTN			
4 3 SOL. W. RESIN PAINTS CONSUMPTN	9 4 TOTAL WASTE DEGRATION	9 5 SEMI-SOLUBLE INCINERATION			
5 33 MURDER SEWAGE TREAT	9 31 WASTE TREATMENT TREAT	9 32 PULP SEWAGE TREAT			
6 33 PULP SEWAGE TREAT	9 34 INCINERATION OF SOLID WASTE	9 35 WASTE BURNING			
7 33 OPEN TREATMENT	9 37 MUNICIPAL INCINERATION	9 38 ON-SITE INCINERATION			
8 33 LANDFILL - FROM AIR CONTROLS	7 40 OTHER DUMP & LANDFILL	14 1 COAL/SYNTHETIC COAL FUELS			
9 33 LANDFILL - FROM AIR CONTROLS	14 31 UNDEVELOPED COAL MINING	14 32 SURFACE MINING-EASTERN			
10 33 SURFACE COAL MINING	14 32 COAL/SYNTHETIC COAL FUELS	14 33 COAL			
11 33 SURFACE MINING-EASTERN	14 37 COAL-SYNTHETIC FUELS	14 38 COAL-SNG			
12 33 COAL CLEANED / NOT DRY	14 37 COAL-SYNTHETIC FUELS	14 39 COAL			
13 33 COAL CLEANED / NOT DRY	15 1 INDUSTRIAL WASTE OF NAT GAS	15 2 NATURAL GAS PROCESSING			
14 33 COAL CLEANED / NOT DRY	15 4 INDUSTRIAL WASTE OF NAT GAS	15 30 SCOUR NAT GAS PROCESS PLANTS			
15 33 COAL CLEANED / NOT DRY	15 4 INDUSTRIAL WASTE OF NAT GAS	17 1 PHOSPHATE ROCK			
16 33 COAL CLEANED / NOT DRY	16 1 RED MEAT PACKING HOUSES	23 1 RED MEAT PROC-PROCESSORS			
17 33 COAL CLEANED / NOT DRY	23 2 RED MEAT PACKING HOUSES	23 31 COMPLEX SLAUGHTERHOUSES			
18 33 COAL CLEANED / NOT DRY	23 30 SINGLE SLAUGHTERHOUSES	24 1 FLUID MILK-COTTAGE CHEESE			
19 33 COAL CLEANED / NOT DRY	23 33 HIGH PRICED PROCESSING HOUSES	24 2 ICE CREAM & FROZEN DESSERTS			
20 33 COAL CLEANED / NOT DRY	24 3 NATURAL PROCESSED CHEESE	25 3 POTATOES			
21 33 COAL CLEANED / NOT DRY	25 2 CANNED/REFRIGERATED FRUIT-VEG-NEC	25 6 APPLES			
22 33 COAL CLEANED / NOT DRY	25 5 TOMATOES	25 7 CITRUS			
23 33 COAL CLEANED / NOT DRY	26 1 INDUSTRIAL COMPOST OF COAL	26 2 INDUSTRIAL COMPOST OF OIL			
24 33 COAL CLEANED / NOT DRY	26 4 COAL MILLING	26 5 INDUSTRIAL STARCH & GLUTEN			
25 33 COAL CLEANED / NOT DRY	26 3 INDUSTRIAL MILLING	26 31 COAL DRY MILLING			
26 33 COAL CLEANED / NOT DRY	28 2 BEET SUGAR	28 30 CANE SUGAR - CRYSTALLINE			
27 33 COAL CLEANED / NOT DRY	35 1 INDUSTRIAL COMPOST OF COAL	35 2 INDUSTRIAL COMPOST OF OIL			
28 33 COAL CLEANED / NOT DRY	35 4 MOVING PAPER (CIGARETTE) MILLS	35 5 ADVEN FABRIC FINISHING MILLS			
29 33 COAL CLEANED / NOT DRY	35 30 MOVING PAPER FINISHING MILLS	35 31 ADVEN FABRIC FINISHING-SYNTHETICS			
30 33 COAL CLEANED / NOT DRY	35 33 ADVEN FABRIC FINISHING-SYNTHETICS	35 34 ADVEN FABRIC FINISHING-SYNTHETICS			
31 33 COAL CLEANED / NOT DRY	36 2 PIECE DYEING-CARPET PRINTING	37 1 COOL SCOURING			
32 33 COAL CLEANED / NOT DRY	36 30 TEXTILE FABRIC FINISHING-SYNTHETICS	38 31 INDUSTRIAL COMPOST OF COAL			
33 33 COAL CLEANED / NOT DRY	41 1 TINTED PRODUCTS PROCESSING	47 1 INDUSTRIAL COMPOST OF COAL			
34 33 COAL CLEANED / NOT DRY	47 3 INDUSTRIAL COMPOST OF NAT GAS	47 4 INDUSTRIAL COMPOST OF COAL			
35 33 COAL CLEANED / NOT DRY	47 6 NSSC - PULP	47 7 GROUNDCO - PULP			
36 33 COAL CLEANED / NOT DRY	47 9 PULP - OTHER	47 30 KRAFT - BLEACHED			
37 33 COAL CLEANED / NOT DRY	47 32 NSSC - SODIUM	47 33 NSSC - ANHYDRA			
38 33 COAL CLEANED / NOT DRY	47 35 OTHER WASTE PAPER	47 36 DYEING			
39 33 COAL CLEANED / NOT DRY	47 71 KRAFT - BLEACHED	47 72 KRAFT - BLEACHED (SCUBBER)			
40 33 COAL CLEANED / NOT DRY	47 75 KRAFT - BLEACHED (LESP)	55 2 INDUSTRIAL COMPOST OF OIL			
41 33 COAL CLEANED / NOT DRY	55 1 INDUSTRIAL COMPOST OF COAL	55 5 ACETALDEHYDE			
42 33 COAL CLEANED / NOT DRY	55 4 ACETALDEHYDE	55 8 DIMETHYL TEREPHTHALATE			
43 33 COAL CLEANED / NOT DRY	55 7 CITRIC ACID	55 11 PHOSPHATIDOL			
44 33 COAL CLEANED / NOT DRY	55 10 ACETIC ANHYDRIDE	55 14 PHOSPHORIC ACID			
45 33 COAL CLEANED / NOT DRY	55 13 PLASTICIZERS	55 17 ETHYLENE OXIDE			
46 33 COAL CLEANED / NOT DRY	55 16 FORMALDEHYDE	55 20 CHLORINE			
47 33 COAL CLEANED / NOT DRY	55 19 PHOSPHORIC ANHYDRIDE	55 23 SULFURIC ACID			
48 33 COAL CLEANED / NOT DRY	55 22 HYDROLYTIC ACID	55 26 TITANIUM DIOXIDE			
49 33 COAL CLEANED / NOT DRY	55 25 SODIUM CHLORIDE	55 30 ACETALDEHYDE-SILVER PROCESS			
50 33 COAL CLEANED / NOT DRY	55 28 SODIUM CHLORIDE	55 33 FORMALDEHYDE-SILVER PROCESS			
51 33 COAL CLEANED / NOT DRY	55 32 ACETALDEHYDE-SILVER PROCESS	55 36 CHLORINE-ETHYLENE CELL			
52 33 COAL CLEANED / NOT DRY	55 35 CHLORINE-ETHYLENE CELL	55 39 CHLORINE-ETHYLENE CELL			
53 33 COAL CLEANED / NOT DRY	55 38 SODIUM CARBONATE-ETHYLENE CELL	55 71 SULFURIC ACID-ETHYLENE CELL			
54 33 COAL CLEANED / NOT DRY	55 41 SULFURIC ACID-ETHYLENE CELL	55 72 SULFURIC ACID-ETHYLENE CELL			
55 33 COAL CLEANED / NOT DRY	59 1 PHOSPHATE FERTILIZER PLANTS	59 32 FERTILE SUPERPHOSPHATE			
56 33 COAL CLEANED / NOT DRY	59 31 PHOSPHATE FERTILIZER PLANTS	61 1 INDUSTRIAL COMPOST OF COAL			
57 33 COAL CLEANED / NOT DRY	59 34 INDUSTRIAL SUPERPHOSPHATE	61 3 INDUSTRIAL COMPOST OF NAT GAS			
58 33 COAL CLEANED / NOT DRY	61 3 INDUSTRIAL COMPOST OF NAT GAS	61 7 PHOSPHORIC ACID			
59 33 COAL CLEANED / NOT DRY	61 5 ALUMINUM SULFATE	61 10 POTASSIUM SULFATE			
60 33 COAL CLEANED / NOT DRY	61 6 HYDROGEN PEROXIDE				

Table P-4. (Continued)
The Industrial Subsectors in the
Input-Output Table of INFORUM

51 11	COAL OIL	61 12	5 DIM CUMENATE	61 13	SOLUBLE METAL
61 14	COAL SILICATE	61 15	COAL SULFATE	61 16	COAL TARS
61 17	COAL TARS	61 18	COAL TARS	61 19	COAL TARS
61 20	COAL TARS	61 21	COAL TARS	61 22	COAL TARS
61 23	COAL TARS	61 24	COAL TARS	61 25	COAL TARS
61 26	COAL TARS	61 27	COAL TARS	61 28	COAL TARS
61 29	COAL TARS	61 30	COAL TARS	61 31	COAL TARS
61 32	COAL TARS	61 33	COAL TARS	61 34	COAL TARS
61 35	COAL TARS	61 36	COAL TARS	61 37	COAL TARS
61 38	COAL TARS	61 39	COAL TARS	61 40	COAL TARS
61 41	COAL TARS	61 42	COAL TARS	61 43	COAL TARS
61 44	COAL TARS	61 45	COAL TARS	61 46	COAL TARS
61 47	COAL TARS	61 48	COAL TARS	61 49	COAL TARS
61 50	COAL TARS	61 51	COAL TARS	61 52	COAL TARS
61 53	COAL TARS	61 54	COAL TARS	61 55	COAL TARS
61 56	COAL TARS	61 57	COAL TARS	61 58	COAL TARS
61 59	COAL TARS	61 60	COAL TARS	61 61	COAL TARS
61 62	COAL TARS	61 63	COAL TARS	61 64	COAL TARS
61 65	COAL TARS	61 66	COAL TARS	61 67	COAL TARS
61 68	COAL TARS	61 69	COAL TARS	61 70	COAL TARS
61 71	COAL TARS	61 72	COAL TARS	61 73	COAL TARS
61 74	COAL TARS	61 75	COAL TARS	61 76	COAL TARS
61 77	COAL TARS	61 78	COAL TARS	61 79	COAL TARS
61 80	COAL TARS	61 81	COAL TARS	61 82	COAL TARS
61 83	COAL TARS	61 84	COAL TARS	61 85	COAL TARS
61 86	COAL TARS	61 87	COAL TARS	61 88	COAL TARS
61 89	COAL TARS	61 90	COAL TARS	61 91	COAL TARS
61 92	COAL TARS	61 93	COAL TARS	61 94	COAL TARS
61 95	COAL TARS	61 96	COAL TARS	61 97	COAL TARS
61 98	COAL TARS	61 99	COAL TARS	61 100	COAL TARS
61 101	COAL TARS	61 102	COAL TARS	61 103	COAL TARS
61 104	COAL TARS	61 105	COAL TARS	61 106	COAL TARS
61 107	COAL TARS	61 108	COAL TARS	61 109	COAL TARS
61 110	COAL TARS	61 111	COAL TARS	61 112	COAL TARS
61 113	COAL TARS	61 114	COAL TARS	61 115	COAL TARS
61 116	COAL TARS	61 117	COAL TARS	61 118	COAL TARS
61 119	COAL TARS	61 120	COAL TARS	61 121	COAL TARS
61 122	COAL TARS	61 123	COAL TARS	61 124	COAL TARS
61 125	COAL TARS	61 126	COAL TARS	61 127	COAL TARS
61 128	COAL TARS	61 129	COAL TARS	61 130	COAL TARS
61 131	COAL TARS	61 132	COAL TARS	61 133	COAL TARS
61 134	COAL TARS	61 135	COAL TARS	61 136	COAL TARS
61 137	COAL TARS	61 138	COAL TARS	61 139	COAL TARS
61 140	COAL TARS	61 141	COAL TARS	61 142	COAL TARS
61 143	COAL TARS	61 144	COAL TARS	61 145	COAL TARS
61 146	COAL TARS	61 147	COAL TARS	61 148	COAL TARS
61 149	COAL TARS	61 150	COAL TARS	61 151	COAL TARS
61 152	COAL TARS	61 153	COAL TARS	61 154	COAL TARS
61 155	COAL TARS	61 156	COAL TARS	61 157	COAL TARS
61 158	COAL TARS	61 159	COAL TARS	61 160	COAL TARS
61 161	COAL TARS	61 162	COAL TARS	61 163	COAL TARS
61 164	COAL TARS	61 165	COAL TARS	61 166	COAL TARS
61 167	COAL TARS	61 168	COAL TARS	61 169	COAL TARS
61 170	COAL TARS	61 171	COAL TARS	61 172	COAL TARS
61 173	COAL TARS	61 174	COAL TARS	61 175	COAL TARS
61 176	COAL TARS	61 177	COAL TARS	61 178	COAL TARS
61 179	COAL TARS	61 180	COAL TARS	61 181	COAL TARS
61 182	COAL TARS	61 183	COAL TARS	61 184	COAL TARS
61 185	COAL TARS	61 186	COAL TARS	61 187	COAL TARS
61 188	COAL TARS	61 189	COAL TARS	61 190	COAL TARS
61 191	COAL TARS	61 192	COAL TARS	61 193	COAL TARS
61 194	COAL TARS	61 195	COAL TARS	61 196	COAL TARS
61 197	COAL TARS	61 198	COAL TARS	61 199	COAL TARS
61 200	COAL TARS	61 201	COAL TARS	61 202	COAL TARS

PAGES 0195

.....

469 068 SectionIV

Date Due